FOOD SCIENCE FOR ALL

AND A NEW SUNLIGHT THEORY OF NUTRITION

By

M. BIRCHER-BENNER, M.D.

Translated and edited with an introduction
by
ARNOLD EILOART, B.Sc., Ph.D.

LONDON: THE C. W. DANIEL COMPANY

CLOTH, **3/6** ; POSTAGE 3d.

LIFE & HEALTH OF MIND & BODY

BY

FLORENCE DANIEL

Author of *Woman's Mental Activity, A Teacher of Brain Liberation, Of Children, Of Babies, What to Eat and How Much, Food Remedies, The Healthy Life Cook Book*, etc., etc.

Food and the Body
Food and Religion
Food and Fantasy
Food and the Life
Thought and the Body
Religion and the Body
Thought and Feeling
Work and Health
Notes on Psychology

London :
THE C. W. DANIEL COMPANY

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LECTURES TO TEACHERS
OF DOMESTIC ECONOMY

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GRAHAM HOUSE, TUDOR STREET, E.C.4

MADE AND PRINTED
IN GREAT BRITAIN

First Published: 1928

"The nutrition problem is one vast marvel, and keeps one in a constant state of amazement at one's self. For the naïve layman the most natural thing in the world, for the investigator of nature it conceals the ultimate riddle of life."

C. L. Schleich.

INTRODUCTION

"THIS is the only book on food I ever came across that was not *stodgy*." Such was the verdict of a housewife who is also an idealist. People write about ideal food, it is true, but their ambrosia is food only for the gods, the immortals (from whom it derives its name—Greek *a brotos*, no death); and now here is a book which tells us that the true ambrosia is within our reach, that it is "not too good for human nature's daily food," that it shall give *us* lasting health and beauty.

Other books have told us about the particular kinds and proportions of atoms of which our food should be composed, until these too became as "stodge" for our minds; this book takes us to the newly-discovered world *within* the atom, and shows us how we may have two atoms of the same kind and one of them shall differ from the other one in glory according as one shall have been sun-illumined and the other not. Other books tell us that our food should be sunned because the sun increases its vitamin content; but they do not tell us how the sun makes vitamins, or why, when they are made, they can never be seen or weighed. This book attempts to explain these facts, and for both facts—the creation of the vitamins and their properties—the explanation is the same. And this is where the author, taking his science with him, soars into the Empyrean and tells of the planetary system of electron orbits* within the atom, and of electron

*The latest theories of the atom have eliminated the idea of electron orbits.

revolutions so delicately poised that they are susceptible to a single ray of sunlight ; and they do not respond indiscriminately to any single sun-ray, but definitely to a particular group or chord of rays whose rates of vibration, in order to be effective, must bear a definite relation one to another ; just as, to make a musical chord, the rate of vibration proper to each note must bear a definite ratio to the rates of its fellows. Thus do the silent symphonies of solar radiations store up power within the atoms, power which is given up as nutritive energy to the plant of which the atoms form a part ; and so the food is literally attuned to our taste and to our needs by the Lord of Harmony, who said, " Let there be light," and who by this means attunes our bodies to his grace.

As to the " potential " of the necessary light, all that is certain is that sunlight is sufficient. But whether its high potential (corresponding to 6,000° C.) is necessary, is not definitely established. It may be, *e.g.*, that the lower potential of the electric arc (corresponding to 4,200° C.) would suffice, since it is known that its rays, for a time at any rate, greatly forward plant growth.

Other books advocate natural food ; this book suggests a reason for the fact that cooking degrades food—or at any rate, the best food. And yet it is not merely since the learned and the orthodox were telling poor people how to economise by cooking their cheese, and thus making it more digestible. But to a poor family cheese is an expensive food of which they could easily digest far more than they can possibly buy. True, even they would have difficulty in digesting cheese they haven't eaten and can't get ; but they know better than to attempt to meet this difficulty by subjecting the miserable bit they can afford to a process which robs it of a

great part of its nutritive value. The Scots ploughman, too, knows better than this when he eats his oatmeal half-cooked because "it stays longer with him." And it has recently been shown that with rats food goes four to five times as far when raw as when thoroughly cooked.

Much of the most valuable and practical of Dr. Bircher-Benner's teaching is due to his distrust of science—the ever-changing, and, to the mass of mankind, the unknown or incomprehensible—as a guide to diet, and his exaltation of the sense of Taste as the true guide. And here, as in his advocacy of uncooked food, the author's teaching will meet with opposition which I believe to be unjustifiable, and which, therefore, I will do my best to overcome. For most people are afraid of trusting to Taste. "Eat what I like ! ! ! But I like so many things that disagree with me. I should always be ill." And it is not only the Puritans, not merely those who are happy only in the conviction that to be happy is to be wicked, who thus protest. There is a basis of truth in the protest. In our artificial, unwholesome environment, the sense of taste is so unhealthy that few persons can eat whatever they like without suffering for it. But there are few or none who suffer from not eating what they don't like. The true doctrine is, then: "Don't eat what you don't like, and, when by thus following—perhaps for years—its negative dictates, you have sufficiently purified your Taste, then and not till then you may safely follow Taste's positive behests and eat what you like." And it will be found that Taste soon demands an increased proportion of uncooked food, especially if cooked food be kept out of ken until there is a distinct desire for it. If you have only one uncooked meal a day, it is most important that it should be the first meal;

because in the morning after the night's fast the body is more or less purified and is more ready to enjoy pure food ; but if you take cooked food for the first meal this will degrade your taste so that you will crave cooked food for the second meal also. The proverbial "apple a day," taken after the night's fast and also after you have become really hungry, will do far more good than in any other circumstances.

A comparison of this edition with the original German will show that (with the author's collaboration) a number of changes have been made. Among these one of the most important is a modification of the statement that animals do not derive energy direct from the sun. I have long inclined to the belief that they do ; and this on the strength of various observations which would otherwise have been very difficult to explain, *e.g.* :

(1) There is a greater desire for food on sunless days, and this beyond what any difference in temperature might account for.

(2) I often begin a sun-bath hungry and end it less hungry.

(3) A prolonged sun-bath sometimes gives a feeling of languor comparable to the satiety caused by a full meal. Is it possible that the sun has formed in the skin vitamins in excess of the needs of the system ? If so, it is time we modified our policy of consuming all the vitamins possible, and began to guard against excess of them as of other foods.

(4) In Barbados, where—so far as material food was concerned—a great part of the population was sadly under-fed, I found universal cheerfulness and even gaiety, which I could only attribute to the perpetual sunshine in which the people were bathed.

(5) I know a girl who was born in June and who from then till the end of September was exposed to

the light for many hours a day in the open air. According to her mother, she took during this time not one-tenth of the food ordinarily consumed by an infant of her age. (So the mother suckled another child as well.) She was offered food four times a day, but usually she would suck once or twice and then contentedly and persistently turn away and go to sleep. Yet by the end of September she weighed only one pound less than normal, and in energy and vivacity was far above normal. During October, with less light and air, she took more food (three ordinary meals a day), and at the end of that month her weight was normal. At eight and a half months she walked freely ; and now that she is a woman and a mother, she is far above the average in health and energy.

These observations are not sufficiently definite to serve as proofs, though they may serve as incitements to research ; but now at length they are supplemented by the definite proof that a vitamin (D) is formed by the action of sunlight on the skin. It is probable that this action will be most marked during a fast. Then, the vitamin being needed by the system, and used up as fast as it is formed, a greater speed of formation may be expected. In this way we may train ourselves, as it were, to receive more and more energy from the sun ; and our descendants should inherit this capacity in enhanced degree.

And here, to show that the physicists are looking in the same direction as our author (a physician), let me quote from a book which may well be read in conjunction with the present volume :

" The radiant influence of light nourishes life and within human body forms the fabric of consciousness . . . . it is certain that life, light and consciousness are bound together by some undis-

covered law. This secret of nature's alchemy is still hidden from us within our own bodies. By revealing it physics will create a new hope for man."*

Readers of the following pages will find that an instalment of this new hope is already presented to them. To take one example: If we accept the figures quoted by Dr. Bircher-Benner, 96 per cent. of our food is used to supply energy, and only 4 per cent. to replace tissue lost by wear and tear. There is, then, no *a priori* reason why more than 4 per cent. should be supplied in the form of material food. Now, if the other 96 per cent. could be supplied in the form of energy, of sunlight, thus reducing the weight of food required to one twenty-fifth of its present amount, this would entail such a diminution in the organs and the work of both digestion and assimilation that the wear and tear would be far less than at present, so that almost the whole of our present rations could be superseded by sun-rays.

The viscera being thus rendered almost entirely superfluous, their bony protections and supports could be dispensed with, and the circulatory. respiratory and nervous systems could be greatly reduced. To transport the diminished body much smaller legs would suffice; and especially for those classes of the community who were in a position to supply their needs independently of their own muscular labour, the problem of flight would be greatly simplified. "A little lower than the angels"!

. . . .

A.E.

**Archimedes, or the future of physics*; by L. L. Whyte.

PREFACE

The American physiologist McCollum on the basis of his researches into nutrition and diseases of nutrition, which lasted many years, arrived at the conclusion " that food is an essential if not indeed the most important cause of spiritual, moral, physical and cultural development and of power of resistance against diseases." Because I share this belief with him, and because, with him and many others, I see how, through widespread false theories and prejudices, there is fostered among us—ay, fostered with conviction and with love—a mode of nutrition which from generation to generation heaps disease upon disease, increases our anxieties for our children, prematurely ages the parents or snatches them away, and at extravagant cost and huge loss uses up the nutritive power of the land, therefore by the publication of these lectures I seek to give every thinking person the opportunity to acquaint himself with the results of researches into nutrition.

I shall strive to make myself understood by all; but it is impossible to write so that the reader shall be spared the trouble of following quite new lines of thought. I risk this, however, because I have seen how great and how keen is the interest in this life-problem. Many and many a one feels that it is of fundamental importance for health and life. *The food question clears the way for the mind question, which then is exalted above the former, and the social question is dependent on both and conditioned by both.*

He who loves his child and his fellow-man will welcome the exertion of thorough reading, thorough thinking and assimilation; and moreover he will fill his thought-world with something beyond the occurrences of his everyday life.

CONTENTS

FOOD SCIENCE FOR ALL

FIRST LECTURE

The process of nutrition—The three foodstuffs—The nutritive salts—The vitamins.

In undertaking to introduce you to the problems of the modern science of nutrition, I must express my gratification at your interest in these important questions and in my standpoint with regard to them. On the other hand it is with great trepidation that I find myself compelled to enter with you a region of which scarcely the first outlines are fixed. The nutrition question is a question of immense difficulty ; it has the difficulties that beset all the questions encountered in the natural sciences and in biology, but aggravated by the complications and perplexities which custom, food-ethics, prejudices and the demands of practical life are continually accumulating. Every day, every illness, raises questions of nutrition, demands a definite answer, a decision. How often would one have been compelled to say : " That I don't know. That is not yet known " ; and how often have circumstances, prestige or routine forced even from learned lips a statement which was not only without any scientific basis but also was full of uncontrolled errors ?

Concealed ignorance, prejudice born of obscure cravings, or premature conclusions from the earliest

scientific discoveries, flourished in the domain of human nutrition ; and few can estimate even to-day the grave injuries which these chimeras of false theories have inflicted and still inflict on the health of the people.

No one knew WHAT IT WAS THAT NOURISHED in the food. For a long time we were told : proteid ; then : calories. But we shall see that all necessary proteids and calories cannot maintain life either in an animal or a human being. There was complete lack of any central point of view from which could be understood the composition of human foods, their complicated structure, their selection, their nature, and the importance of their digestion and assimilation—in short the dietetic or food-value of the food.

Now into this chaos pregnant with mischief the last thirty or forty years have brought a change, at least in the realm of science, though by no means in the life of the population of Europe. New life has entered into the nutrition-problem. A goodly number of distinguished investigators have directed their industry to it, so that to-day a *new* science of nutrition is coming into being. In what follows we shall have occasion to name some of these investigators and to discuss their work.

Let us now turn to the nutrition-problem which in brief outline I will set before you. But first let me appeal for your indulgence, for the five hours at my disposal force me to an incomplete and imperfect exposition.

I

In the living organism we observe a series of phenomena whose connection with the process of nutrition and the ingestion of food is self-evident.

First of all there is the increase of the living substance through *growth*. Every living being begins its existence as a single cell, a structure which even in the human being is of almost microscopic minuteness. At birth the little human being newly born has brought this up to a weight of three to five kilograms, and the adult of twenty-five years has a weight of fifty-five to seventy kilograms of living substance. After growth ceases, the weight is maintained for many years, despite all waste of tissue, which can only be brought about by a constant replacement of the material used up.

Secondly, there is in the human organism constant generation of heat and performance of work, from the gentle beating of the resting heart and the regular motions of respiration, up to the considerable muscle performances in bodily work, in sport or in the ascent of mountains, accompanying which there is much concealed work done by the digestive organs, the internal glands and excretory organs, and the nervous system.

Side by side with this we see a third phenomenon, how this living human body selects from surrounding nature a limited multiplicity of substances and introduces them into its inside, the weight of matter thus introduced exceeding by many times the weight added by growth, so that one must ask what becomes of the excess within the body.

And finally we see as a fourth phenomenon how by breathing the organism continually takes into itself atmospheric air and expels altered air.* These four phenomena taken together embrace the essentials of the process of nutrition.

* The volume expelled is slightly smaller but the quantity (weight) is considerably larger. The bearing of this fact on the question raised in the preceding paragraph is evident.

Ed.

The substances ingested in this process are called foods, or, as a whole, *food ;* and we will here note at once that this fulfils a two-fold task, viz. to provide :—

(1) suitable building material for growth and formation of substance.
(2) suitable " fuel " for the production of heat and strength or energy. For this second task it requires the oxygen of the atmospheric air, which in breathing penetrates into the blood.

Of water and its great importance for rendering possible life and its maintenance we cannot here speak. It is as it were only the carrier of the process of nutrition, but takes no part in it.

The process of working up these substances within the organism is called assimilation. What remains of the food-stuff and the oxygen at the end of the process of assimilation—the end-products or waste—leaves the body through the intestines as dung, through the kidneys as urine, and through the lungs as carbonic acid. A remarkably eventful process slowly transforms the food until finally the end-products, the waste, result as a residue of no further use. Between the material phenomena of the food and those of the end-products, the urine and the dung, lies the secret of nutrition, distributed into all sorts of separate processes such as : the digestive process, the assimilation (making the food one with the living cell-substances), the transformation of energy (formation of muscular strength and of the nerve-currents), finally the destruction, the breaking down (" dissimilation ") till the residue can be cast out as end-products.

Please note that the conception of assimilation

by no means refers only to the building up of living substance but also to the production of energy, the life *work*. There exists an intimate connection between the exchange of substances and the exchange of force. This will be clear to every one when he remembers that, in the "stuff," food, there are energies lying hidden which presently will feed the flame of life. From the "stuff" of the end-products these energies have disappeared, and yet this stuff was also the stuff of the food.

For this mighty process of working up the food, the organism has made for itself an arsenal of workshops, laboratories, factories and arrangements of all kinds which we call organs and systems. To enumerate and describe them all, to explain their astounding activities, and withal to show how marvellously one fits in with another so that ultimately the whole works harmoniously, all this were a task that would amply repay itself, for no one could be insusceptible to *this* revelation of a higher wisdom. But here I must confine myself to the briefest possible survey.

If we follow the entry of the food into the body we encounter first the digestive organs : the mouth, with the teeth, saliva, and organ of taste, is connected by the œsophagus with the stomach as receptacle for whole meals and as chemical laboratory with acids and ferments. With the stomach is connected the duodenum, in which, through canals that open into it, the great digestive glands—the liver and the pancreas—mingle their digestive juices, the gall and the pancreatic juice, with the chyme.

Next comes the seven-metre-long small intestine out of which as out of a reservoir the liquefied food passes in a steady continuous stream all day long into the blood-stream of the intestinal wall, and so

into the interior of the body, so that, even with an empty stomach, the person is secured for many hours against any need of food. Finally in the large intestine collect the used up masses which have not been found worthy to enter into the interior, and then after a final revision they are ejected through the rectum. By means of the immense vascular system which permeates all these organs with a network of finest ramifications there take part in the digestive processes: the blood with its red and white corpuscles, the heart with its driving power, and the lungs with their contribution of oxygen and their means of freeing the blood from carbonic acid. Between the cells of the intestinal wall, a system of lymph-capillaries absorbs valuable food-juices and after careful testing and purification bears them through the lymphatic glands into the circulating blood. After the blood streaming through the stomach and intestine has saturated and loaded itself with food-material, it pours through the portal vein into the liver, which now as a last filter strives to separate out and hold back everything injurious or poisonous, so that, in the blood leaving it, only a pure nourishment may reach the general blood-stream.

AND ONLY NOW DOES THE FOOD REACH THE PLACE where it is to be used, be it the growing tissues, the working muscles, the guiding nerves or the thinking brain.

Then wherever there has been nourishing, living, consuming, blood and lymph carry away the waste-products, and transport them to the excretory organs which also perform extremely important work for the process of nutrition.

Interspersed in this long process of food-assimilation you must imagine a series of highly important regulatory arrangements, which accelerate or re-

tard as may be needed, call forth nutritive processes or countermand them. Without such regulation no nutrition can proceed properly. These arrangements, too, are connected with organs specially constructed for them, which suffer and become ill if they are burdened with an unsuitable nourishment. And alas! if it should reach such a pass that the regulators no longer function well. Then occur those grave diseases which are known and feared, *e.g.* (in consequence of disordered action of the thyroid gland) under the names of goitre, cretinism, Basedow's disease, or (in consequence of disordered action of the supra-renal bodies) "high blood-pressure," Addison's disease. Of these we shall speak later.

Such a regulatory relation to the nutritive process has above all the human *skin*, which forms the surface of our body. Not only because it helps to bring about the extremely important regulation of temperature, but because in it there take place also highly important, as yet too little investigated and too little noticed, nutritive processes in which the penetrating sunlight plays a part, and which are as decisive for the course of assimilation as is the activity of the internal glands: the thyroid, the thymus, the supra-renal bodies, the pineal gland, and the sex glands which indeed,—you will here note—are organs specially constructed for regulation.

Finally there are two nervous systems which take part in the regulation: the sympathetic nervous system which, as it were, feels every least alteration in the chemical nature of the blood and at once, by stimulating the regulatory organs, applies any necessary correction, and the central nervous system, which employs or checks the whole nutritive apparatus as higher points of view may demand.

OF THE ACTION OF THE LATTER a Russian investiga-

tor Pawlow, gives an impressive example.* In order to observe the work of the stomach he made a little window in the stomach of a dog and so was able to observe how the mucous membrane of the stomach secreted a plentiful supply of juice as soon as a bit of meat was held before the dog's nose. But if for the meat he substituted a cat, the stream of juice was suddenly held up, while the dog was agitated with all the excitement and rage of his race against the hereditary enemy. Let it never be forgotten, then, that all emotions, joy as well as pain, anger, disgust, fear, love and hate, through the medium of the central nervous system, exert an important influence upon nutrition.

Thus then you have before you a slight sketch of the process of assimilation. Included therein, as you have already heard, is the *transformation of force, the consumption of energy*. Assimilation and energy-process are identical in so far as the former does not serve the building up of the substance of the body. But so far as they are identical, they simply show us one and the same process from two different angles of vision ; so that one may follow and elucidate the process either by way of the chemical substances or by way of the energies concerned.

But the chemical and the energetic are two quite different methods of investigation. While the former loses itself more and more in a mass of small details, so that finally no general view is possible, the latter sweeps us up to a spacious height where all details vanish and we have a full view of the whole.

This is connected with the content of the two

*This may make more than one impression. For instance : are experiments on dogs necessary to show, among other things, that emotions react upon nutrition ? and does the thirst for knowledge justify such experiments—*Ed.*

conceptions matter and energy. These also mean one and the same thing, but energy means a higher perception of the *one substance* of the world; it approaches the hidden essence more nearly than matter which merely represents the perception of substance by our senses.

We must not be surprised, then, if we find it impossible to penetrate the nutrition problem unless our thinking rises to the exertion of acquainting itself with the thing called energy—so wonderful and not, after all, so difficult; with that *one, invisible,* which brings about all that happens in the Universe—the birth and revolution of the spheres, the light of sun and stars, the warmth of spring and summer, the circulation of water, the sounds of speech and of music, the flashes, the flaming sheets and the thunders of the lightning, the splendour of colours, and finally the vast multiplicity of substances from the most rarefied gases to gold, platinum and the heaviest of all, Uranium.

II

Now that we have satisfied ourselves, then, that the organism is adapted, in a manner scarcely suspected, for the elaboration and utilisation of the food, our interest turns more and more to the food itself. What, then, really *is* food? What the nourishing principle in it? Which food constituents are needed for building up the living substance of our body, which for carrying on life or consumption of energy? In what relation as to quantity do these two claims on the food stand to one another? What conclusions do we draw as to nutritive value and the selection of food?

That it was no easy matter to find an answer to the question: "What really is food?" will be most

readily appreciated by one who knows the difficulties encountered in the investigation of the material world.

Only gradually, and only after mastering a mountainous mass of research-work was it possible to prove that all the known substances of our world may be decomposed into ninety-two *elements*. Accordingly—it was argued—the food too is composed of elements, and not only food but also all bodies which life forms out of matter, whether in the vegetable kingdom, the animal kingdom or the human body. And it appeared that all forms of life upon earth, and accordingly the foodstuffs also, are composed of *fifteen elements*. I give here the names of these fifteen elements with their atomic weight :

Elements	Atomic Weights.
1 Hydrogen	1.0
2 Carbon	12.0
3 Nitrogen	14.0
4 Oxygen	16.0
5 Fluorine	19.0
6 Sodium	23.0
7 Magnesium	24.3
8 Silicon	28.3
9 Phosphorus	31.0
10 Sulphur	32.0
11 Chlorine	35.4
12 Potassium	39.1
13 Calcium	40.0
14 Manganese	54.9
15 Iron	55.8

(Besides these a few other elements occasionally form part of living bodies, *e.g.*, iodine, with an atomic weight of 126.9.)

These fifteen elements are so to speak the build-

ing-stones with which life—with the help, let us at once add, of sunlight—produces its abundance of marvellous structures, beginning with the simplest plant-cell and including the most perfect flower, the humming-bird and the elephant, the speaking eye and the gleaming gold of the beloved's hair. To prove the existence of the elements it was necessary to burn the various forms of life, *i.e.*, to abstract from them all that could feed a flame, all sunlight which as energy had been interwoven by life into itself. Now, again, there they lay, apparently lifeless ashes, and yet every one was convinced that they hid a secret; a secret which life knows and uses; a secret of the elements which acts in the food also.

Of this secret we shall speak again later. In the meantime these ashes appeared simply as dead material of which little was known. The properties of the elements, which belong also to their ultimate particle, the atom, were known. So many elements, so many heaps of atoms, the atom of one element different from the atom of the other, different especially in the atomic weight. Known, too, was their readiness to combine with one another, energy being thereby either set free or absorbed (stored up). Combinations of atoms, whether of one element or of different elements, are called molecules, and the substances formed by molecules composed of atoms of different elements are called, not elements, of course, but compounds. Thus two atoms of hydrogen combine with one atom of oxygen to one molecule of water; thereby energy becomes free. The two elements are gaseous substances, their compound, water, is a liquid: that which results from combination has new, different properties.

That which strikes us first of all with regard to

the fifteen elements of the life-substances is the *low atomic weight.* The great number of valuable elements of higher atomic weight are not employed by life at all. Silver (107.8), gold (197.2), mercury (200.0), platinum (195.0) and uranium (238.5), substances, so highly valued by man on account of their properties, are altogether despised by life. And, of the biogenic elements, hydrogen, carbon, nitrogen and oxygen, the lowest atomic weights, are in quantity by far the most considerable components of living substances. The reason for this selection is at once evident. By the use of these elements of low atomic weight, life is able to store up *a great quantity of energy* in a small quantity of matter.* Already, then, it appears that before all else life is concerned with energy. In using the substances which form its structure it creates mighty stores of energy.

A further group of the fifteen elements is distinguished by properties which are of decisive importance for all chemical reactions, as they are representatives, either of the acid principle, *e.g.*, fluorine, silicon, phosphorus, sulphur and chlorine, or of the opposed alkali principle, *e.g.*, sodium, magnesium, calcium, potassium and manganese.

Here it must suffice simply to mention that within our body, in the blood, in the cells, in the juices, in short, under the conditions of life and in all

*The force of this argument will be more readily appreciated with the aid of an illustration based on the fact that elements of higher atomic weight are heavier than the biogenic elements. Thus an average-sized man made of platinum (atomic weight 195) would weigh about one and a half tons. His one ton wife, however, would have no occasion to dread the weight of his displeasure, for, unless he possessed energy exceeding that of a man of flesh and blood, he would be unable to stir hand or foot : the quantity of matter is out of all proportion to the quantity of energy therein.—*Ed.*

assimilation, the proportion of the acids to the alkalies is of decisive importance. On the right proportion depends the healthy course of assimilation. But too much acid means sickness and even death. This group, with the addition of iron, contains all those elements which are called the mineral substances of the food, or the food-salts. By way of supplement to the above, I may mention that iron has its special use in the blood (in the haemoglobin) for the transportation of oxygen and of carbonic acid; that phosphorus with [in the free state] its tendency to emit light is everywhere prominent where a great transference of energy is taking place: in the muscles and in nerve-substance.

Now what is to be made out of the elementary composition of the vitally important substance—which by the way forms the food also—this perhaps is not so evident as you might wish. At any rate, I hope that this is how you feel. For I am happy to be able to say that this meagre beginning is about to find a most wonderful and promising continuation, since modern physics has found an entrance and an insight into the interior of the atom.

Presently I shall find occasion to return to this point and to speak of the interior of the atom when we have surveyed the heretofore accepted theory of the nutritive substances, and are ready to attempt the discovery of the hidden principle of nutrition. But now, following the historic course of investigation, we must turn to the compounds—for you now know the meaning of this word—which as "foodstuffs" have been discovered in foods.

The recently deceased poet-physician, Carl Ludwig Schleich, whose genius enabled him to picture what happens in the secret workshops of nature and of life, tells us that the Son of God, banished to a

lonely region of the earth, caught sunbeams and wrapped them round grains of dust so that they all became little sun-globules, with which he formed all sorts of fantastic creations : little plants and animalcules. When God came to look after his son he rejoiced greatly in these creations, and at his son's request he breathed into them the breath of life. And they began to move, to multiply, and they spread themselves over the whole earth.

Now that is a tale at once charming and true. The grains of dust are our fifteen elements, in part already transformed into simple compounds, water, carbonic acid and ammonia. With them and with the sunbeams caught in the vegetable kingdom—we shall see later what a far-reaching application this has—life, guided by the creative power and wisdom, forms its sun-globules, the organic substances, of which every body of plant or animal (and accordingly our food also) consists.

Under other names you have already long known these organic substances. Anyone who has ever heard anything of nutrition knows them classified as proteids, carbohydrates and fats. Each of these names signifies a group of many substances differing among themselves, but in essence related. It is characteristic of the proteids that their molecule contains nitrogen ; and therefore they are more correctly called nitrogen-containing—or for short, N-containing substances (N is the initial letter of the Latin name *nitrogenium*, for nitrogen). As N-containing substances they contrast with the N-free carbohydrates and fats, which two groups are constructed out of carbon, hydrogen and oxygen.

Now these three groups of substances form the chief components of all human foods, and it is these too with whose breaking down to carbonic acid, urea and water assimilation is principally concerned,

for which reason they have received the honourable title " foodstuffs."

Their discovery was accompanied by another, a fundamental discovery: that life cannot exist without the N-containing substance. Protoplasm and nuclei of living cells proved everywhere to be composed of proteid substances.

NITROGENOUS SUBSTANCES, PROTEIDS AND LIFE—inseparably linked with one another! To what a dizzy height grows at once the vital value of nitrogen! This mysterious gas which mixed with oxygen is inspired as air but leaves the lungs again unused; which can with such difficulty be made to combine with other elements! What special property can give it such value for life? Is it again a question of the binding of energy, since its compounds with carbon, oxygen and hydrogen, such as nitro-glycerine, exhibit immense explosive power? But only in the vegetable kingdom are the complicated proteid molecules of living substance built up, only there where the energy of the sun is absorbed and interwoven with craving for life. What rare, undreamed of, vitally important connection between plant and animal, plant and man, is here suddenly revealed to the student of nature! All that grows, all that blooms everywhere around us, and which everyone holds so dear, is seen to be one of our most fundamental conditions of life!

Thus, then, had become apparent one of the first demands that must be made on food; in order that life may continue in us, the foods must contain nitrogen which by the art of life within the plant has been built up together with carbon, hydrogen, oxygen, sulphur and sometimes phosphorus into polyatomic proteid molecules.

It was in the forties of the last century that the great chemist, Justus Liebig, brought the chemistry

of food up to this point. As he believed moreover that proteids provide not only the building-material of living substance, but also muscular power, he regarded it as the nourishing principle. To him carbohydrates and fats were simply respiratory substances; *i.e.*, they provided heat only. In this belief originated the first scientific valuation of food: its proteid content represented its nutritive value. Any food—let us take lentils as an example—is rich in proteid—very well, then—most nourishing; another food, *e.g.*, potatoes—is poor in proteid, therefore, but slightly nourishing. Fresh fruits have on the average a very small percentage of proteid, accordingly no nutritive value worth mentioning; dried fruits have a considerably larger proteid content, and accordingly a considerable nutritive value.

Moreover, as Voit calculated that the adult weighing 70 kilograms (154 lb.), doing average work, must take 120 grams (4¼oz.) of proteid daily, it appeared that of food rich in proteid one must take only a small quantity, but of one that is poor in proteid one must take quite fantastic, impossible quantities in order to be nourished. And these quantities spoke in urgent tones especially to medical men to whom fell the task of strengthening persons with weak appetite, or perhaps even suffering from indigestion. The result was, of course, a contempt for vegetable food "*of which one must eat such frightfully large quantities in order not to suffer from hunger.*" What unreasonable and dangerous overloading of the stomach and intestine!

BUT HALT! Are these conclusions correct? Are the Liebig-Voit statements justified? No—they are in the main a fundamental error. It is true that proteids are indispensable for *building up* living substance, but, as the physiologist Rubner

has shown, they are quite unsuitable, one may say bad, sources of muscular power, indeed of energy in whatever form it may be used ; they are sources of energy only in so far as the carbohydrate constituent of the proteid molecule possesses energy-value. The true sources of energy are the carbohydrates and the fats. *So greatly did Liebig err !*

This is all the more important since of the daily energy-income construction needs only 4 per cent. while consumption of power needs 96 per cent. To maintain muscular work with proteids, then, instead of with carbohydrates, would be like heating our rooms with mud and coal instead of with good pure coal.

But the Voit proteid figure has also proved incorrect. Instead of 120 grams proteid daily only 30 to 50 grams are necessary, according to the source of the proteids. For the proteids in different foods are not, as was then thought, equal in dietetic value, but very different. Of all this we shall have to speak later in more detail. By way of supplement we will only mention here that Nature confirms this in surprising fashion in the composition of human milk, in that for the quickly growing nursling she supplies only 7 per cent. of the daily energy-income in proteid and 93 per cent. in carbohydrates and fats. Human food is, as Rubner said, distinguished by its striking poverty in proteid.

In view of the great resistance which the goddess Nature opposes to any penetration of her secrets, natural science and biology have had to pay for their progress with many an error. But seldom has an error had such unhappy consequences. If the excess of proteid above the 4 per cent. necessary for constructive purposes had been only a bad source of energy, then the dissemination and the

practice of the Liebig-Voit doctrines would not have been so disastrous. But the excess of proteid, which from that time onward was used more and more to supply energy consumption, burdened assimilation so heavily that assimilation diseases and their sequelae began to rise from generation to generation, and from this the people's health suffered and still suffers grave injury. For the Liebig-Voit doctrines are to this day the centre of gravity of the nutrition theory which is taught to the people in the higher schools, including the schools of domestic economy. Yes, they are unfortunately still the centre of gravity in many dietaries for the sick, in the hotel cuisine even of the health resorts—pardon me—*horribile dictu.* I would only remind you of the well-known *Tables of Food Values,* which are everywhere displayed in teaching the theory of nutrition. They show in coloured columns the percentage content of foods in proteids, carbohydrates and fats. Everyone, and certainly every elementary school-teacher, notices there the foods poor in proteid and rich in proteid, *i.e.,* the "inferior" and the "nourishing." Thus the error entered into daily life and firmly established itself there, so that to-day it is a many-headed hydra which swallows many wanderers through the vale of life.

It would be no misfortune if these Tables should entirely disappear from education. The percentage of proteid is no measure of the nutritive value of a food. Just as the horse, the ox, and the elephant can amply supply their need for proteid with grasses and herbs, so can man supply his modest need even from fresh fruit and nuts. And here we come to a great injustice which these mistaken teachings have done to the noblest food of the human race, the vegetarian diet, by grievously

lowering its nutritive value in the eyes of the ignorant populace. As Cato invariably concluded his speeches in the Roman Senate with the words: *Ceterum censeo, Cartaginem esse delendam*! so would I say again and again: *Ceterum censeo, hanc injuriam esse redimendam*—this injustice must be set right!

III

With the investigation of these three groups of foodstuffs the food question was by no means closed. First of all the mineral substances had to be investigated more in detail. But here I can only briefly notice these investigations for I have already given too much time to what precedes.

The vitally important mineral substances such as phosphorus, sulphur, sodium, potassium, lime, silica, fluorine, magnesium, manganese and iron are also interwoven in the secret laboratories of plants growing in the light, with one another and with the organic molecules, and we have not yet succeeded in gaining a true insight into their organisation within these huge atomic structures. In the red colouring matter of the blood *e.g.* one

Provident Nature gives therefore to the newly-born child an excess of iron to take with him into the world, an excess just sufficient for his needs during the nursing period. After the nursing period therefore, milk alone is an incomplete food, which would bring about lack of iron, and therefore poverty of blood. Fluorine which is indispensable for the formation of the enamel of the teeth, is found in sufficient quantity, so far as is known at present, probably only in rye, for which reason the peoples who eat wholemeal rye-bread have the soundest teeth. More serious, however, is the mineral deficiency caused by certain modes of preparing foods, such as the preparation of white wheat flour and white bread, the extraction of sugar from natural sugar-containing foods and the pouring away of the water in which vegetables have been boiled. White bread and milk, even if to the latter one adds coffee, are according to Bunge —let this never be forgotten—the diet most suitable to impoverish a man's blood. Bunge shows too how easily deficiency in lime may occur, since flesh and many prepared foods, in particular confectionery, are poor in lime. He strongly recommends therefore giving children, instead of these, fruits which are rich in sugar and in lime. Another investigator, Hugo Schulz, stated that deficiency of silica often occurs, leading to disorders in the hair, the skin, the eyes and elsewhere.

From these few indications, then, you already see that the mineral substances are very important foods, which are as indispensable for life as are the proteids. Here and there it may dawn upon you that in this respect, in unwitting innocence, grave sins are committed in the kitchen and in the composition of ordinary dietaries; and both domestic science and the science of nutrition have

every reason to take these facts into account. But the more seriously the mineral content of a food has been interfered with, the more the victims take to common salt, which, as Bunge says, "mercilessly ill-treats" the kidneys and is quite incapable of replacing the lacking minerals.

You have now surveyed the material components of food. Are the riddles of nutrition thereby solved?

Bunge, too, asked himself this question. He composed a food—artificial milk—which contained all the substances which, according to the physiological doctrine of the time, were necessary to sustain life; and with it he fed—mice. The animals very soon died. They lived not longer than with carbonate of soda alone.

This experimental result is the answer.

There is an incorruptible Judge as to the value of any theory of nutrition:—Life. Is life sustained? Is normal growth possible? Are the descendants healthy and vigorous? Is health, is full capacity for work maintained? These questions the Judge answered in the negative. Before this result the investigators stood confounded. The physiologist, Forster, exclaimed: "A mysterious region lies before us, the entrance to which is at present closed and as to whose extent we scarcely know more than the ancients of the ocean, the world-stream."

But life is kind to the investigators also: through a discovery made by the Dutch physician Eijkman in the realm of disease, the investigation of the materials of the nutrition problem received a new impulse.

In his researches into a disease very widespread in certain regions of India, Beriberi, "great weakness," he observed that this disease flourished among those peoples whose food consisted mostly of *polished* rice, while those tribes who ate *unpolished*

rice escaped. His attention was thus directed to the fine, silvery, membrane which covers the white rice grain. What had this membrane to do with that grave illness, and with nutrition in general ?

Eijkman fed poultry with polished rice ; they fell ill of Beriberi. Now to the same food he added the silvery membrane. The hens recovered ! He did the same to the Indians suffering from Beriberi ; they also recovered.

Beriberi, which is also called " general epidemic nerve-inflammation," is a very grave and alarming disease. Such then is the consequence of an error of diet. Without its silvery membrane the rice-grain is an incomplete food which acts like a strong assimilation poison. The silvery membrane evidently contains a supplementary something which converts the rice-grain into a complete food. Is this supplement a substance ? It was supposed so, and the yet unknown substance received the name *vitamin*. Then further researches showed that for all kinds of grain the like relations existed, that *e.g.*, a goodly amount of white wheat flour and white bread in the food also produced Beriberi. Many a case of so-called " poverty of the blood and nervous debility " among us may be a disguised attack of Beriberi.

Researches into vitamins lasting for years followed this discovery and threw many a light on nutrition diseases, the " avitaminoses," whose causation was not understood. Prominent in vitamin research have been : Casimir Funk, the Americans, McCollum, Osborne and Mendel, the Frenchmen, Bierry, Portier and Baudoin-Fandard, and others.

In connection with the treatment of the nutrition question in these lectures, the following must be added concerning the vitamins.

Presently there were discovered many other disorders and diseases whose cause was the lack of "*unknown* substances" (vitamins, supplementary substances) in the food. Strangely enough no one has yet succeeded in finding these substances and preparing them in a state of purity. It could only be established that there are three* kinds of them distinguishable by their effects :

1. "Unknown substances" with the diet factor A. They are soluble in fat and are found in the leaf-like plant-organs of cabbage, spinach and other vegetables ; are plentiful in tomatoes and in fruits in general, also in butter-fat, unskimmed milk, yolk of egg, cod-liver oil and in the kidney-fat of the pig. It seems that the A-substances have something to do with the yellow colouring matter in carrots and in the yolk of eggs. Roots and tubers contain more of it than seeds, but less than leaves and fruits. The amount in milk depends on the fodder.

The chief source of the A-substances are plants ; animals are incapable of synthesising them.

If the food lacked the "unknown substances" with the factor A, then, in spite of the presence of all other known food stuffs, one observed : wasting away, swelling of the eyelids, diminution of growth and of appetite, dryness of the conjunctiva (mucous membrane of the eyes) and of the cornea, and finally blindness and death.

2. "Unknown substances" with the diet-factor B. They are soluble in water and are always present in sufficient quantity in natural foods of vegetable origin, also in whole seeds and whole grains. Flesh and honey are poor in B-substances. They are but slightly sensitive to heat yet a temperature of 120°C (248° Fahrenheit) prevents their

*Other kinds have since been discovered.—*Ed.*

action ; hence preserves are poor in B-substances. By pouring away the water in which vegetables have been cooked, they are lost.

A food which lacks this factor B produces the "great weakness," or Beriberi disease, *polyneuritis epidemica*. Because the B-substances are a protection against this nerve inflammation they are called also anti-neuritics. They excite the activity of the digestive glands, so that when they are lacking the appetite diminishes. A food insufficiently supplied with them causes catarrh of the large intestine, enlargement of the supra-renal bodies and oedema, degeneration of the sex-glands, whence supervenes sterility and cessation of the monthly periods.

In the course of this avitaminosis three stages can be distinguished : In the first the organism uses up its stores, hence no symptoms as yet. In the second the organism furnishes itself with vitamins at the expense of certain organs (liver, sex-glands) and through enlargement of the supra-renal bodies with increased secretion of adrenalin. In the third stage the supra-renal bodies are not in a condition to furnish enough adrenalin, there is a considerable fall in the body temperature and finally death results.

Beriberi spread over Labrador and Brazil owing to excessive use of sifted flour. In the English army on a diet of preserved meat, white bread, biscuits and marmalade this disease broke out in Mesopotamia and at the Dardanelles.

The "unknown substances" with the diet-factor B are also formed only in the vegetable kingdom.

3. "Unknown substances" with the diet-factor C. These too are soluble in water, very sensitive to heat and to long keeping. Even Pasteurising

destroys the C-substances. The foods richest in the C-substances proved to be the leaf-like plant-organs and the fruits, but in the fresh not in the dried state. The C-substances of cabbage and of tomatoes withstood boiling.

Lack of the factor C is the cause of scurvy. The increasing consumption of preserves in America led to an increase of scurvy. In the year 1916 there were more than 11,000 cases of scurvy in the English army in India.

In these scorbutic diseases also enlarged supra-renal bodies and lack of adrenalin were found.

The " unknown substances " with the diet-factor C are also formed only by plants.

What do these results of vitamin research tell us ?

If it is with you as with me, the first and deepest impression is a feeling of painful astonishment that errors in nutrition apparently so small should result in such grave diseases. Errors in nutrition which for so long a time no one recognised, and which are still everywhere committed daily in unsuspecting ignorance and the inertia of custom.

There is first of all the " modern," " improved " diet which robs of the vitamins our daily bread and everything that is made of flour. Then there is sugar, the foodstuff which the plant builds up out of light and in its organs mixes in well-considered proportions with minerals, other foodstuffs and vitamins ; this is torn from its natural accompaniments, and in utter contempt of the laws of nutrition added in arbitrary proportions to the daily food. Then the juice of grapes and of barley is thrown away to feed the yeast fungi which seize upon the foodstuffs and the vitamins, and mix the worthless residue with their excretion, alcohol ; and these intoxicating products the deluded human being takes to be strengthening and exhilarating gifts of nature.

Then there is the general belief that only by cooking do foods become really digestible and valuable, so that there are persons, and in particular invalids, who never eat anything at all in its natural raw state; persons to whom fresh fruits and salads are positively forbidden as the epitome of all that is injurious; persons whose whole food without exception is subjected to boiling heat. And yet the very first results of vitamin research showed us that heat destroys essential nutritive values. If on such a diet the dissatisfaction and misunderstood craving of the deluded palate is unnaturally increased, people seek to soothe it with stimulants and senseless food-mixtures; and by way of constantly providing sufficient variety they manufacture preserves which in consequence of the destruction of the vitamins accelerate the descent into chronic nutrition diseases. Thus Germany, threatened with famine, forbids the consumption of fresh fruits and cooks them up into marmalades, destroying the nourishing power of her soil. The nut-trees are used for gun-stocks; and fifty per cent. of the fruit-trees are of such quality that their product is only fit for alcoholic fermentation. In the town-dwellings there are no fruit-cellars, or the building by-laws permit only cellarage in which the fruit will not keep. In short a Babylonian confusion prevails in this foundation of human life, in nutrition. And in apathetic immobility the wisdom of the wise looks on. But wherever one awakens, to him the "slight" errors in diet become grave—"gross." Thus on the strength of his vitamin researches McCollum comes to the conclusion "that food is an essential if not indeed the most important source of spiritual, moral, physical and cultural development and of the power of resisting disease."

Let us give yet a glance merely at the earliest

recognised, the most evident, the most brutal results of these "slight!" errors in nutrition, behind which a whole army of graduated disorder of the health of the whole population can hide themselves. The Dutch physiologist Sjollema is indeed of opinion that we have yet to determine how far the origination of other diseases (*e.g.* tuberculosis) is favoured by insufficiency of certain food-factors.

In what characteristic and at first completely incomprehensible fashion does this lack of unknown supplementary substances affect the stability and condition of the healthy organism? Now it is the eye that is affected and may eventually be entirely destroyed; or again it is the nervous system and the blood, so that paralysis and dropsy mark the way to death; and a third time (scurvy) it is the mucous membranes and the blood-vessels that are attacked, so that the blood finds its way into the body-cavities, the joints, and even into the tissues, abscesses are formed and the teeth fall out. But besides this the effects of lack of vitamins in the food extend to all the essential phenomena of life: growth may be hindered or brought to a standstill; sterility, shrivelling and inactivity of the sex-organs, deterioration and degeneration of the children may result; while the gravest phenomena are preceded by falling out of hair, constipation, loss of appetite, and diminution of strength. Do not forget that all this happens notwithstanding that the food contains all necessary foodstuffs and minerals, as commonly understood, and happens because yet "unknown substances" are lacking in it. Quite new and surprising, and at the same time of incalculable future importance for discovering the secret organisation of the process of nutrition, are the interactions between the vitamins in the food and the

processes in those already mentioned regulatory organs, the glands which from within pour their secretions into the blood (therefore called endocrinic glands) : supra-renal capsules, thyroid gland, etc. When there is deficiency of factor B the supra-renal capsules are seen to swell and to secrete more juice (adrenalin), while simultaneously other endocrinic glands shrivel up. For a time this adrenalin is capable of replacing the factor B and of staving off the collapse. Thus the factor B acts like an internal secretion and the like holds for the factors A and C also.

Now to-day the diseases of the endocrinic glands have received from physicians more attention than ever before, since these diseases are constantly becoming more widespread and more severe. To counteract them organo-therapy was introduced, *i.e.*, the patient must ingest in some form that animal gland substance which is equivalent to his injured gland. For some time the animal organ is capable of moderating the symptoms of disease. Are we to remain content with this ? To-day the whole conception of these remarkable diseases—here I mention only the goggle-eye disease, connected with disordered thyroid activity and even with goitre—is based on the fact that all the symptoms arise from a diseased endocrinic gland, often from several together. The cure then is supposed to be either operation or the taking of the corresponding gland substances, such as thyroid, insulin, etc. But when the cause of the damage to internal glands lies in a damaged and incomplete food, even then shall the last word rest with organo-therapy, shall further thousands upon thousands fall ill through wrong feeding and then only be painfully sustained between health and sickness by these far from harmless gland substances ?

Or: shall we not prefer to restore a natural and correct diet for which the vitamin researches now give such plain guidance? I well know that I am now speaking of subjects altogether medical, but these medical matters concern you personally far more than you may think. There is scarcely a family in Switzerland which does not suffer from "endocrinic disturbances." I think, therefore, that there can hardly be an even half-educated and thinking person who would not rightly be interested in this question.

The investigators of these questions have applied themselves also to the English disease (rickets) and to pellagra (red skin disease) and have found that here too "unknown substances" or the proportions of two mineral substances such as phosphorus and lime, but also and in the same sense deficient exposure of the skin to sunlight, play a causative rôle. This shows that:

Sunlight
the as yet hidden essence of the vitamins
and the mysterious action of the internal glands

have in them something akin, secretly connected, even equivalent in action and yet interdependent, and that *the nourishing* principle must be hidden not only in the three foodstuffs, but also herein. Whether by another method we can get any nearer to this hidden something, you will see in the following lectures. But do not forget that as yet no one knows what the vitamins really look like, whether they are substances at all or perhaps only mathematical relations of the fifteen elements, and effects of the molecular structures under the guiding wisdom of life and the energy of the sunlight.

These extremely valuable new results of nutrition-investigation are indeed only beginnings of a real knowledge, but like a gloomy sunrise the con-

sciousness is dawning that a part of the civilised peoples of Western Europe, through the deterioration of their diet which for the last seventy years has been rapidly growing, are undergoing a process of slow suicide. *Videant Consules.*

SECOND LECTURE

Calories and nutritive value—The central point of view—The amount of " fall " of chemical nutritive energy.

To-day I must repeat : the fact that I am undertaking to present to you within a few hours, so far as this is possible for me, problems which penetrate into the depths of life, overcomes me with a nameless trepidation, although before the holiness that is life my action may find pardon. The sages of former times kept secret their knowledge of the marvels of life, and made it difficult for their disciples to attain such knowledge ; indeed they warned them against it. Only through overcoming obstacles with his own exertions and his own often painful experience could the disciple become worthy of the knowledge and of the truth. You will remember Schiller's impressive poem, " The veiled image of Sais." There the Godhead is made to say ; " No mortal touches this veil till I lift it myself." To me we seem to be standing before the veiled image of Sais, and to be in the act of seeing how the veil begins to rise. And the gigantic image begins to grow, becomes vaster and mightier till it fills the heavens, and overwhelms and oppresses the puny powers of comprehension of every human being who has not through many, many hours of his life prepared, practised and fortified them.

But greatly as I appreciate and admire this standpoint of other times, and deeply as I feel the distance between those wise men and myself, yet in spite of all restraints I am driven to speak, not only

by the honour you have done me in asking it, but by another—an imperative reason—the grave sufferings everywhere around us, which in ever-varying forms come day in day out before me. Look around, I beg you, among your circle of acquaintances and note what is the position after the fortieth year as regards health. Digestive troubles, falling bowels and floating kidney, deformity and clumsiness due to accumulation of fat, fatty degeneration of the heart and want of breath, rheumatic and gouty diseases, liver and kidney pains, asthma and bronchitis, goitre and lung troubles, sick headache, high blood pressure and calcification of the arteries, ulcerated legs and cutaneous eruptions,—you will find a shocking number of such victims who through one or other of these or similar troubles are cheated out of all beauty and joy in life.

But in youth too, even among children, you will find suffering enough, arising from the same causes ; and many of the results, moreover, will be hidden from the observer, since they affect the invisible mental life whose tragedy is the greater the less one can or will see it. All these sufferings are the consequences, direct or indirect of many years of sins of nutrition arising from appetite, error or ignorance.

AND ALL THESE SUFFERINGS CAN BE AVOIDED, CURED OR ALLEVIATED BY A HEALTHY NOURISHMENT.

The comparatively small number of these joyless sufferers who find the way through the maze of remedies and prejudices to the nourishment that brings health always ask me in amazement : " Why has no one shown me this way before ?"

Lately I met in the street an elderly gentleman, whom twenty years ago the correct diet had cured of digestive troubles which had continued for years. He came up to me and said : " Do you know how much I spent on doctors and druggists before I came

to you, and how much in the twenty years from the day of your treatment until to-day ? I have looked through my books and reckoned it out. Before, twenty-five thousand ; since, one thousand francs."

Under the vivid impression, constantly renewed, made by the sinking of so many valuable human beings into the abyss of nutrition-diseases and of their sequelae down to the third and fourth generation, I must solve the mystery and speak ; and I think that with you my words will be in good hands. Your influence on the coming generation of housewives and mothers is unique, far-reaching and lasting. Wise women are far better fitted to free themselves and their families from the bondage of injurious habits, than men, who in questions of nutrition are often unpractical.

I beg you then again to follow with patience what I have further to say.

Yesterday we studied the theory of the material components out of which food is built up. At the close we came upon components, presumably material, which no one knows, but whose action has been recognised, proved and investigated,—upon the vitamins, the unknown substances, factors A, B and C, or, as Carl Ludwig Schleich called them, the creative substances. How remarkable that at the end of the material investigation stands a mysterious something that has a decisive action, and yet cannot be found and weighed. A power that has an effect on life, invisible, without weight, without form. But I have already told you that the theory of the substances can never finally answer a question of life, for substances themselves are admittedly nothing final, are certainly not Nature's last word. That which we call matter resolves itself, when we penetrate more deeply, into energy, as the clouds into the blue sky.

To-day, then, we have to study the energy of food and the energy process of our body.

I assume that the conception of energy is known to you. Energy is the driving, the acting, the moving in Nature, the capacity for work in all phenomena ; the strength of the woodman's arms which swing the axe, the strength of the mountaineer's legs, the strength of the heart-beat which drives the blood through the veins, but also the streaming blood which slowly loses itself in the vascular network ; but equally the heat pouring from the burning coal, the steam pressure in the boiler of the locomotive, the weight of the moving mass of the train as it speeds on its way, of the water flowing in the stream to the valley or rushing down in the waterfall, the yet passive power in the dynamite, which is liberated when it explodes, or the might hidden in the altitude of the masses of snow which is manifested when the avalanche thunders down. Energy also are the vibrations of the sounding violin, and the sound-waves which carry the sound through the air, so are electric potentials, electric ether waves, or the light rays which with the speed of lightning fly through the conducting cable or through space, will drive mighty machines or lift masses of sea-water over the mountains.

Energy manifests itself in attraction and repulsion, in motion, heat, light, electricity, magnetism, in chemical transformations. All that our senses perceive is energy. Only as the result of energy do we experience anything of the surrounding world, of the existence and the actions of our fellow-men and finally of ourselves.

The living organism is a static energy creation. With the help of an example of a quite simple energy creation of this kind you will at once realise what this means.

We light a stearin candle. Now over the wick is formed a flame of definite shape and size. In the course of hours the candle will become shorter, but the flame will always remain the same. Shape and size are conditioned by the quality of the stearin, the suction of the wick, the oxygen content of the air and the inner details of the combustion process. A thicker mass of stearin round the same wick would not make the flame larger but would extinguish it ; but in pure oxygen the flame would be larger, hotter and more brilliant. This conditioning of the shape and size of the flame by regulating force relations is the standing, *the static* in this energy creation which internally is in a state of constant change. The stearin is the fuel carrying the energy—the food—of the flame in which there is a continuous transformation of the chemical energy of the stearin into heat- and light-energy.

In principle the life-process of our body is just such a static energy creation only indescribably more highly organised and more finely thought out and calculated out. The place of the stearin is taken by all that the human being has to eat. The suction of the wick corresponds to the digestive and assimilative capacity of the individual. As there heat and light pour forth from the flame, so from the transformation of the food-energy in us spring muscular force, nerve and brain-currents, sensations, feelings, emotions, powers of growth and healing, the warmth of the normal body-temperature and the fiery heat of fever which destroys the armies of the bacteria. Thus it is a fact that all the phenomena of life which we perceive with our senses are transformed energies which spring from the chemical energy of our food.

As in the candle the wick sucks up the stearin in a slow uniform stream and conducts it to the flame, so

the capacity for work of our body draws from the reservoir of the small intestine the needed amount of energy in a slow continuous stream. Whether we take five meals or three or only one meal a day, that makes no real difference in the inflow of energy, but the consumption varies considerably between a possible minimum and maximum (the rest of deep sleep and the most extreme physical labour), which is rendered possible by a complete system of regulators.

The first insight into this energy-process was afforded by the discoveries of Lavoisier published in the year 1777 under the title " On Combustion in General." According to this treatise there is in atmospheric air a " vital air," oxygen ; and combustion is nothing else than the combination of combustible substances with the oxygen of the air. According to this our candle-flame sucks up not only stearin but also the oxygen of the surrounding air, and this oxygen combines with the carbon and hydrogen in the stearin. The resulting compounds are carbonic acid and steam, both gases, which escape from the candle-flame. Now, as the life of the body also continually consumes oxygen from the inspired air, and as foodstuffs are known to be in great part composed of carbon and hydrogen, and, further, since from the body also carbonic acid and water are continually escaping, the question arose whether the energy-process of life is also a process of combustion, like flame. " Impossible ! " will reason instantly reply, for the phenomenon of fire, heat, flame is lacking. True, we are warmer than our surroundings, but how slight is this warmth compared to the heat of a flame. But if oxygen could combine with carbon and hydrogen so that instead of heat there resulted other kinds of energy ? A cold combustion, so to speak ? If in place of the heat form of energy there resulted the tension of the muscular

fibres and the electric nerve currents ? Then, to be sure, the life-process might be compared with combustion, but one would always have to bear this difference in mind. And so these questions came to be gradually tested.

All human foods may be completely dried and then burnt like coal or wood. Thereby results, for a grain of substance burnt, a measurable quantity of heat. The unit measure of heat is the calorie, that is the quantity of heat necessary to raise the temperature of a litre of water one degree (centigrade).

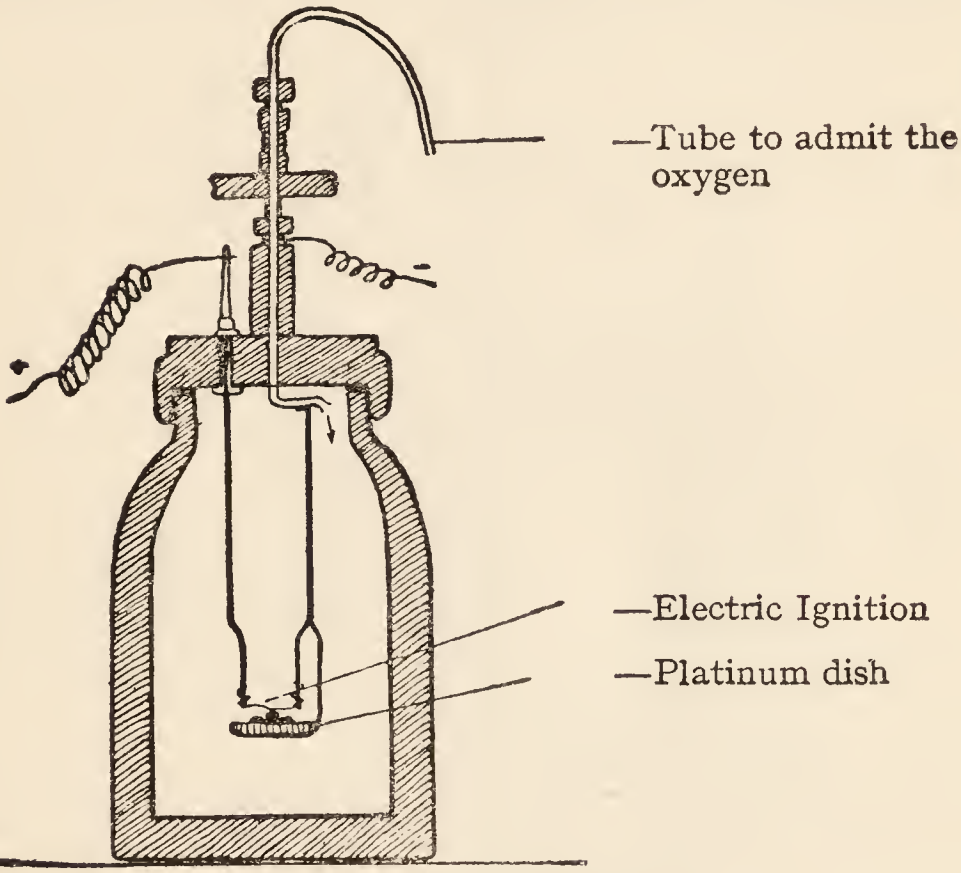


FIG. 1. Berthelot's Bomb

For finding the heat of combustion of a food (or other substance) this shell-shaped steel bomb is used. It is called, from the inventor, the Berthelot bomb (Fig. I). In this strong-walled, tightly closed vessel which is filled with pure oxygen

under a pressure of fifteen atmospheres a weighed quantity of substance is burned in a platinum dish by electric ignition. In a few seconds all is over. All nitrogen compounds are exploded, the free carbon and hydrogen atoms have combined with oxygen, all chemical energy has changed into heat.

Now we have to find out how much heat has

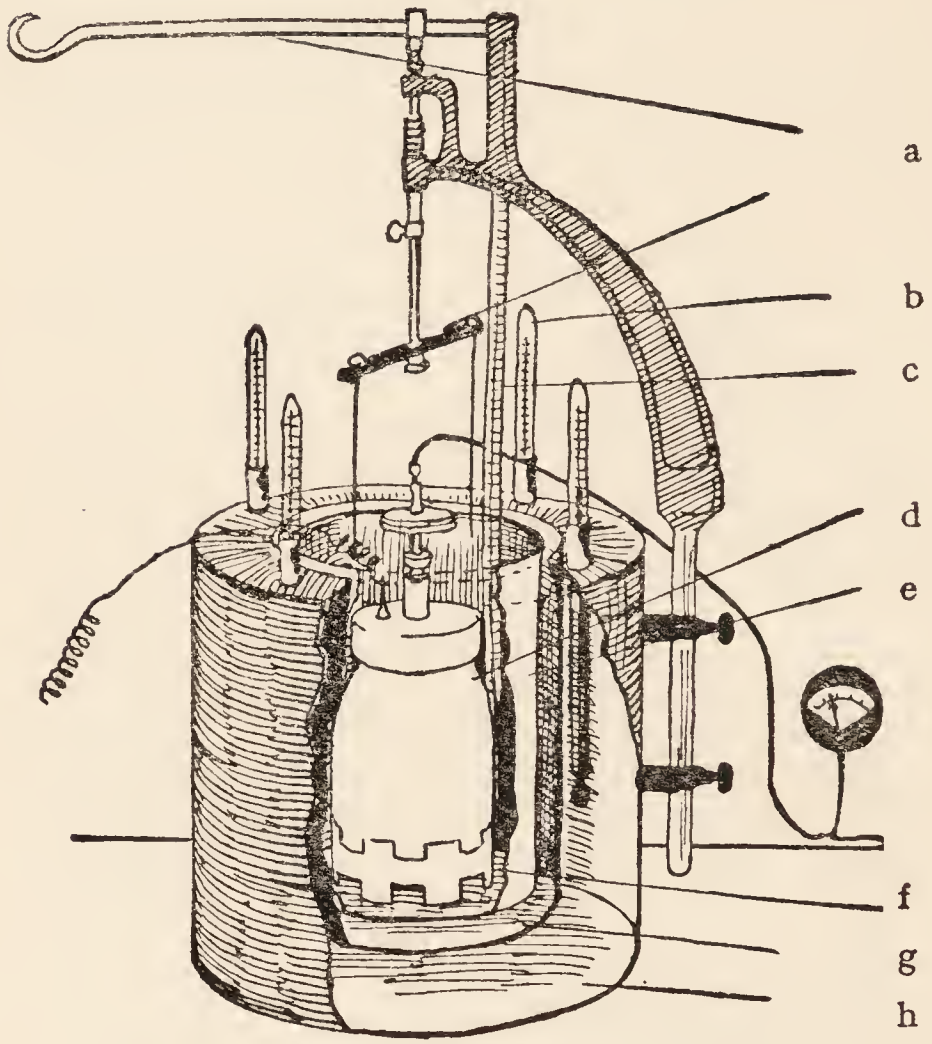


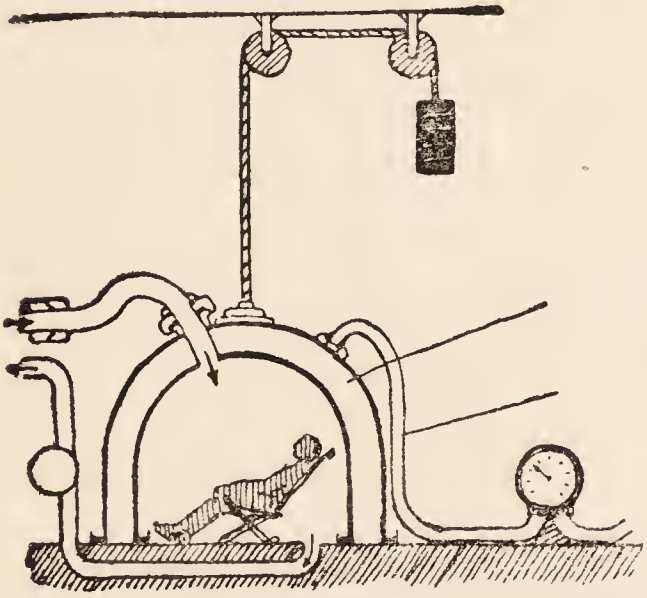
FIG. 2. Calorimeter for the bomb

a. Lever arrangement for agitating the water in the inner mantle to secure uniform distribution of the heat produced. b. Thermometer of the outer water-mantle. c. Thermometer of the inner water-mantle. d. Berthelot's bomb. e. Brass vessel. f. Space filled with water. g. Intermediate space (air). h. Space filled with water.

resulted. To determine this the bomb is placed during the combustion in this calorimeter (heat-measurer) Fig. 2. From the rise in temperature of the water-layer around it the amount of heat formed in the bomb may be calculated.

In this way was determined the heat value of the three foodstuffs, proteid, fat and carbohydrates, as well as that of most human foods.

The next thing was to determine whether the energy which the living body can abstract from the foodstuffs and the foods for carrying on life agrees with their heat value. As all the energies proceed-



—Mantle for absorption of the heat produced.
—Manometer for measuring the air pressure and thus calculating the heat produced.

FIG. 3. A calorimeter cell: air calorimeter according to d'Arsonval

ing from a body including those outside it are ultimately transformed into heat so that finally the whole of the energy liberated from the food can be measured as heat, a calorimetric cell (Fig. 3) was constructed as the dwelling place for a human being wherein he lives, moves and works; and the arrangement of the cell was such that the total heat resulting at the end of all transformation could be exactly measured. In this way it was possible to prove that,

having regard to certain corrections, the life process extracts from a food of known heat value, exactly that heat value, neither more nor less.

From 1 gram proteid life extracts	4.1 calories
From 1 gram fat	9.3 calories
From 1 gram carbohydrate	4.1 calories

If one knows the percentage of these three foodstuffs in a food its calorie value can be at once calculated with ease.

Here we must pause a moment and make sure that we realise the meaning of this discovery. It means that life is carried on by means of food-energy, depends upon the energy content of the food; and that in life also holds the law of the conservation of energy: that no energy appears which was not already there, and none disappears without appearing somewhere else. A far-reaching discovery! For the first time we feel, so to speak, sure ground under our feet with regard to the riddle of life!

The living organism obeys the law of energy.

The energy values of the food determine the nutritive value.

What follows next is this: Since according to Voit a man weighing 70 kilograms needs, per day, when performing moderately hard work, 120 grams proteid, 50 grams fat, and 500 grams carbohydrates, that would be 492 proteid calories, 465 fat calories and 2,050 carbohydrate calories, altogether in round figures 3,000 calories. If the calories determine nutritive value, then proteid calories must be exchangeable for carbohydrate calories or for fat calories, and likewise carbohydrate calories for fat calories and *vice versa*. Experiment showed that to a certain extent this is the case, and so originated the law of substitution values.

But it was soon found that there were unexpected difficulties connected with these substitution values. In particular the proteid calories proved to be worth less than the carbohydrate calories. To save a fasting man from using up an amount of his own body-substance equivalent to 100 calories there were needed of carbohydrates 106.4, of fat 114.5, and of proteid 140.2 calories. Thus the carbohydrates proved themselves the most economical, the proteids the most wasteful providers of energy. Accordingly more than one quarter of the energy stored up in proteids is useless for life and is converted in the body direct into superfluous heat. Rubner calls this diminished power of the foodstuffs their specific dynamic action. It is least in the case of the carbohydrates. Rubner succeeded indeed in showing that the proteids, whose molecule includes a carbohydrate, provide life with power only to the amount of this carbohydrate portion. Impressed by this result Rubner says : " This is the result which is diametrically opposed to the ideas of the specially high value of proteid. . . ."

Rightly to appreciate this result you must remember that the energy requirement of the adult amounts to 96 per cent. of the whole food, so that for this main part proteids are bad providers, acting as it were like dirty wet coal in the stove. This nowise diminishes its irreplaceable value for the small 4 per cent. residue of the demand for food, which serves to build up substance. This important but small proteid demand can readily be supplied by almost any reasonable diet. Nature intended that man should have a diet poor in proteid, as is readily seen in the mother's milk, which even for the quickly growing nursling provides only 7 per cent. of proteid calories.

But sharp and clear is brought to light the fatal

error that a diet rich in proteids is capable of giving strength. Neither with flesh, nor poultry, nor eggs, nor caviare, not even with cow's milk, can one strengthen the weak, much less cure the sick! So many thousands have already had dearly to expiate such ignorant experiments; they have paid for them with early death or with long illness. The excessive proteids in the food are not only a bad source of energy; besides this their breaking down in assimilation grievously overloads the organs, as any chemist familiar with the facts can tell you.

You will be astonished that these results of Rubner's have not been generally known long ago. I was as much astonished at this as you. So I asked Rubner himself about it. He answered that his results are not liked; for no less than 15 years they had been ignored. Why have they been treated in this way?—I will not answer this at present. But the people's welfare demands that every physiologist should teach these results to medical students, that every clinic should have them in mind, so that they should be made use of, and this not only in rare noteworthy exceptional cases, *e.g.* in a children's clinic here and there.

If you have followed what I have said as to the specific dynamic action of the proteids, you have observed that here a considerable difference is already noticeable between the calorie value and the real energy value of the food in carrying on life. When with me you have glanced at the origin and the nature of food energy, you will easily see that calorie value and energy nutritive value are two conceptions which cannot be equivalent. Only from a survey of the whole does the human mind gain courage for the final decisions.

There above us in the firmament burns and shines the mighty star of day, the sun. With its floods of

light it sends out day and night a vast quantity of energy into the universe, of which a small fraction reaches the earth, and even this fraction is an amount exceeding human conception. Where this solar stream of energy strikes the earth's surface, there everywhere bursts forth in spring the verdure and the floral wealth of the vegetable kingdom. From ancient times humanity has felt, and the investigation of nature has long since proved, that between this sprouting, this verdure, this blooming, and the light rays there exists a connection, hidden indeed, but essential. When the woodland leaves shine in light or dark green and when in the deep shade of the wood men are able to shelter themselves from the heat of the sun, this comes about only because the leaves absorb all rays of light except those of their particular green, and beneath the leaves there is no more light. In the leaf of the plant therefore this vast abundance of energy vanishes. At the same time the plants suck up out of the ground with their roots, water, minerals and nitrogen compounds, and out of the air, carbonic acid—that gas which we breathe out—and they grow, building stalks, leaves, roots, trunks of trees, blossoms and fruits. As you may conclude from the principal law, the law of the conservation of energy, the disappearance of the light-energy in the plant-green means only a transformation into a new energy. And again I may take it as known, in part from the first lecture, that with this origination of a new energy, those peculiar structures so rich in energy, the molecules of which the plant-body with all its organs consists, are built up out of nitrogen, carbon, oxygen and hydrogen atoms. And in this form, wherein it is for our senses fixed in rest (and in wood and coal seems to be almost petrified), we call the transformed solar energy—chemical energy of

the organic substance. For those energies which are resting as if fixed, but may by certain methods be roused at any time to new work and transformation, we have a special name—*potential* energy, *i.e.* energy as capacity, in contradistinction to those energies which we perceive hastening through space, or moving masses, and therefore call *kinetic* energy, moving energy. Now we may express it quite briefly thus: the kinetic energy of the sunlight is converted in the plant into potential, chemical energy, so that, in place of the rays so different in their wave-length and of the groups of rays to be discussed later, we have the wealth of molecular structures which the hidden architect of life builds up into the body of the plant. He who has acquainted himself with the origination of organic substance and has penetrated more deeply into its vital meaning, comes to the only possible conclusion, *that these daring combinations of selected atoms to organic molecules are energy-laden systems of very different quality, and that between their quality and the manifold qualities of the rays in the sunlight there must exist a direct relation.* We shall consider later in more detail these relations between light energy and the chemical energy of the organic substance.

When this building up of energy in the plant had been recognised, the question was naturally asked, how is it with the building up of energy in the animal kingdom? In the animal kingdom this process of storing energy in the building up of substance plays such a slight part that in the energy balance-sheet it is negligible. The lower animals, and man also, draw the whole amount of their calculated energies from the vegetable kingdom, whether directly, like the herbivora and frugivora, or indirectly, like the carnivora, which in the flesh and blood of their prey are still consuming plant energies

changed into animal substance.* It had become clear then that the building up of the energy systems for the maintenance of all life upon the earth was entrusted to the vegetable kingdom. Only there is produced the essence of the foodstuffs, of proteids, carbohydrates and fats.

In the vegetable kingdom chemical vital energy is produced from solar energy ; in the animal kingdom it is consumed.

I found myself compelled just now to adopt an unusual expression : chemical vital energy. The general expression chemical energy would not suffice for me. There is a difference. The chemical energy of gunpowder, of dynamite, or even of coal when it is burnt with oxygen, is surely something other than the chemical energy of food. This is as it were a chemical energy with special qualities. By the combustion of coal, too, chemical energy changes into heat calories. In fact from a kilogram of good coal we get 8,000 calories. But we cannot nourish ourselves with coal, still less with gunpowder and dynamite. And as to this difference the calories calculation of which we spoke to-day simply tells us nothing at all. And yet precisely there must be the point of departure for the question of nutritive value. What is the special character of the chemical energy which is built up in the vegetable kingdom, the character worthy of the sacredness of life ?

At this point the results already achieved by science left me in the lurch. I attempted now to solve the riddle myself. Through the determination

*Quite recently it is beginning to be recognised that direct sunshine is of importance for the nutritive processes of man ; and that at least one vitamin, D, is formed by it in the skin ; thus its ultimate effect may be incalculable. But these investigations are still in their first stage, so that they cannot be further noticed here. *Ed.*

of the calorie values of food and the proof that the organism depends upon these values, it was proved that the maintenance of our life is in complete harmony with one of the most important principles of the processes known to us in the universe, with the law of the conservation of energy. This principle is called also the First Law of energy. As there is a first law there must also be a second. This is in fact the case. The Second Law is also called from its discoverer, Carnot's principle. While the First Law—the discovery of the physician Julius Robert von Mayer*—simply says *what* happens and what does *not* happen, Carnot says *when* something happens and *how much*. *Carnot*—a French lieutenant of artillery—had found in the fourth decade of the last century that " a heat machine can only be set in motion when a difference of temperature exists." Moreover " the *work done* by a perfect heat machine depends only upon the difference of temperature." Without difference of temperature no energy-motion, no work. The greater the difference of temperature the greater the work.

The German physicist *Clausius* showed later that this second principle is by no means limited to the theory of heat but represents the general condition for anything at all happening. As, for heat, there is the temperature-difference, so there is—says Wilhelm Ostwald—" in particular for chemical energy also such a ' chemical potential ' and this is the exact expression for that which under the name of chemical affinity has been sought rather than known."

Since the life-process is a continuous happening, an uninterrupted flow of energy, it follows that the general condition for something happening must

*Von Mayer has been called, probably with more accuracy, an early and independent *enunciator* of this Law.—*Ed.*

apply here also. In other words the Second Law of the theory of heat must apply to the flow of vital energy.

Strange to say, this simple, self-evident deduction had never been applied by anybody to the processes of nutrition. I was confronted therefore by a perfectly new and yet evidently quite important question.

How this question occupied me for years, and how gradually I found my way as well as might be through all difficulties, I cannot here describe to you. I would only acquaint you as briefly as possible with the results.

My hand has at its surface a definite " heat potential " or a definite temperature, 30 degrees Celsius. If I take in my hand a glass of water also at 30 degrees Celsius I have no sensation either of heat or of cold. Hand and glass have the same potential. As there is no difference of potential, nothing happens. If however, I take in my hand a glass of water of 60 degrees Celsius something very soon happens ; I at once put the glass down and shake my hand because the heat of the glass is painful. The heat potential of the glass was higher than that of my hand, therefore heat passed out of the glass into my hand. If the glass had had a temperature of only 50 degrees Celsius I should have been able to hold it quietly in my hand and should only have said : it is hot ; had the temperature been 80 degrees, I should have put it down very much more quickly. But if I take in my hand a glass of water of 0 degrees Celsius, I have a sensation of cold and my hand will become cooler and cooler. In this case the heat passes out of my hand into the glass. The energy motion is completely reversed.

From this example you readily see the meaning of the difference of potential. If it is nil the energy

is not set in motion ; if it is greater, the action increases and besides the direction, higher-potential-to-lower, determines also the direction of the motion of the energy. With the potential, then, it is as with the position of a mountain lake which one might use for supplying electricity works with water. The higher its level above the turbines, the greater the power or the fall of its water, the greater the work it will do. The height-difference between lake and turbine is here the potential difference, and in the sense of this illustration one may call the potential simply the energy level.

If now we adopt this point of view for the process of nutrition the food becomes the mountain lake level or the potential of the chemical energy of life. The substances leaving the body at the end of assimilation (carbonic acid, urine- and dung-components) correspond to the valley level of the water leaving the turbines. The difference of the level of chemical energy between food- and excretion-level determines then according to Carnot's law the magnitude of the result or the work of the food in maintaining life.

Accordingly the interest would be transferred at once to the question of the energy level of the food; because carbonic acid, urea and water are always the end-products. Where is the level highest ? To what changes is it subjected in the manifold transformations it undergoes before we consume it ? Now I found that the chemical life-energy of the food has its highest level or potential at its origination from solar energy in the plant. Thus, for my understanding of the nutrition problem, this origination acquired an absolutely central significance. That which hitherto in the search for nutritive values had apparently been left entirely on one side appeared to me the decisive starting-point for forming

an opinion. More and more clearly I came to see that the material forms of chemical energy—*i.e.* the foods—only disguise the nature of the energy that maintains the vital processes ; that between chemical energy as it is stored in the plant and sunlight energy there must exist an essential kinship if not indeed identity, so that *the nourishing*, for him who does not suffer himself to be deceived by externals, *must be the solar energy itself organised by life.*

You will be constrained to grant me that this solar energy organised by life is something other than heat calories. But to this we shall return later.

Now human food is not limited to the food store of the fresh living plants, but materials are also used for food which have been removed by all sorts of transformations from that original level. All these transformations had now to be tested to find whether the energy potential had suffered a change and in which direction ; whether it had risen or fallen.

A difficult task confronted me. How should I measure the chemical potential of whose nature as good as nothing was known ? For the heat potential, the temperature, there was the thermometer ; what measuring instrument then could science give me for the chemical potential ? I began to study chemistry again. A distinguished chemist assisted me. Measuring instrument there was none ; a measurement was not to be thought of. The position became tragic. How should I test my discovery, how secure due recognition for it, if I could not clear up all problems with measured numerical results ?

Then in the chemical energy theory there became known to me simple and clear rules by which one could, not indeed measure, but decide beyond question what alteration the potential suffers by any transformation. Here I pass over this. All

this is stated in detail in the Principles of the Nutrition Theory.*

As result of these considerations it was shown that every transformation which turns the original food energy into another condition, whether by fermentation, decay, salting or the heat of the baking, roasting and boiling processes, or by way of the digestive organs, every transformation in the nature and organisation of the substance of the animal body, through the process of dying of the tissues of the slaughtered animal, finally its changes during storing and manipulating in cooking—every such transformation brings about a sinking of the level. A lower level means less fall for the maintenance of life and therefore less nutritive value.

The meaning of this discovery will be at once evident to you when you hear that it is as much as to say : for human nourishment fruits, nuts, and raw salad have the highest value, bread and cooked vegetables have intermediate value, foods of animal origin have the lowest value.

Now these results agreed quite well with scientific experience (as I showed by many examples, and in particular with the results of Rubner), but were directly opposed to the generally disseminated views of many physicians and especially of the academically educated lay-world, which were based on the earliest errors of the youthful theory of nutrition. Also the experience of the food treatment of diseases was favourable to the new results, in spite of the fact that it was here a question of prevailing, with the help of patience and tenacious endurance, against extremely hostile prejudices and fears.

Of course, my doctrine encountered in many

*Principles of the Nutrition Theory. Berlin. Otto Salle. Fourth edition, 1926.

quarters that contempt and abuse, which is kept in store for vegetarianism. Fortunately this was neither surprising nor discouraging to me; indeed as a young physician before I really knew anything of nutrition, I had myself been no better in my judgments. Although it was by ways quite other than those of the vegetarians that I had come to set plant-food above animal-food, I now learned to value vegetarianism, and after misunderstanding it so long I would heartily admit that to-day every step forward in the investigation of nutrition brings to light new facts in its favour.

To be just, I must add however, that in the presentation of this discovery, so far as it was possible some 25 years ago, there were obstacles to the scientific comprehension of it. The first obstacle was the Second Law and the second the chemical potential. The Second Law is a law difficult to grasp, and its transference from the theory of heat to the domain of chemical energy generally caused difficulties and misunderstandings so that even the great physicist Chwolson had occasion to write a thesis that should purge it from the prevailing mistakes and neglect. How the case stands with the conception of the food potential, you shall hear to-morrow. Since the last formulation of the theory a decade and a half have passed. In this time physics and chemistry have experienced great revolutions whereby a deeper penetration into this central question of the nutrition problem has become possible. The relations between light and chemical energy have become relations between the wave-lengths of the rays and the orbits of the electrons in the atom and in the molecule; and the complex conception of the food potential can be resolved into its components.

THIRD LECTURE

The " miracle " of the daily bread—Light spectra—Into the interior of the atoms—Identity of light and chemical energy—Nutrition potential—Final observations.

" Our daily bread " is such an everyday companion of the human being in his journey through the vale of life, that it seems to him as if it were fully known and familiar to him, as if, as a matter of course, he knew all about it, and there was no reason to look into the thing further. From his earliest days he has known it, has seen and enjoyed it every day. Surely one should know the things that one daily sees and experiences. By bread these people live, and they long for a miracle, and—it will never come.

But the daily bread *is* a great miracle, a mystery. This shows that it is possible for man to be smitten with an astonishing blindness, so that the real miracle is ever passing before his eyes, presenting itself to him, and he does not see it.

When Maeterlinck wished to say what spirit is and what the spirit in men achieves, he wrote his well-known drama " The Blue Bird." This is about a woodman's two children, a brother and sister, sent by the witch Berylune and led by the Light Spirit on a quest for the Blue Bird, which alone can cure the witch's sick child. To the boy, Tyltyl, the witch gives a diadem to take with him, wherein is set a diamond which he has only to turn in order to make the essence of things visible and serviceable. With the help of this he will find the Blue Bird, *i.e.*

" the great secret of things and of happiness." The first time he turns the diamond, everything about him is transformed: the ugly, wicked old witch becomes a fairy or princess of wondrous beauty, who helps the children with the utmost kindness. After a long and eventful journey which takes the children into the land of memory, into the palace of the night, into the castle of delights, into the magic wood, into the churchyard and into the kingdom of the future, Tyltyl and Mytyl wake up again in their little bed in the woodman's miserable hut on Christmas morning. Tyltyl is overwhelmed by the change which everything around him has undergone: the mother, the house, the forest. " Father! mother!" he cries, " what have you done to the house? It is just like it was before but much more beautiful. Everything freshly painted, everything made just right, everything shines so, everything is new—last year it wasn't like this! . . . And the forest? How great and beautiful it is! As if it was new. Heavens! how happy we are to be here."—" Last year " was the evening before, when the children had fallen asleep full of trouble at the disappointment of their Christmas wishes: the year's journey was a dream.

I hardly need to interpret this fairy-tale to you. Witch, diamond, princess and light, are symbols of the spirit, the witch's sick child is the human spirit caught in the material view of the world, which can only be cured if the great secret of things and of happiness is revealed to her, *i.e.* if she finds the Blue Bird. Through this revelation everything will become different, more beautiful, new.

The great secret of things!—This may tempt us to advance bravely and joyfully to the revelation of the great secret of our daily bread.

I

In our yesterday's lecture we had arrived at the conclusion that the information derived from the calorie values of food, as to the nourishing value of the energy of that food, is quite inadequate and indeed untrustworthy and highly unsatisfactory. On the basis of the First Law of Energy it had been believed that the same quantity of heat, whatever its source, could perform the same quantity of work. Thus according to the First Law, one calorie can raise 427 kilograms one metre.

But the Second Law teaches " that a quantity of heat appears the more capable of being transformed into mechanical work the higher its temperature is . . . . with the temperature falls also its practical utility."*

It appears to me that the unequal action of the food calories should have compelled investigators to take the Second Law into account and to turn their attention to the temperature of the food calories. Why this did not happen can be understood only from the fact that the food energy is not heat but chemical energy. But chemical energy possesses apparently no temperature. That which in the case of heat is called its temperature, is called, in the case of chemical energy, its potential, and this potential no one could measure ; indeed no one had any idea what this thing looked like. But this obscurity was no justification for setting on one side, in a problem so vitally important, the temperature, or potential, question, and obstinately persisting in determining by calories the nutritive value of a food. And we get no help from such devices as calculating

*_Exner_, " Lectures on the physical foundations of the natural sciences."

the calorie values into " nem "-values as Pirquet* has done.

The temperature of the calories which are produced in the combustion of food exists surely somewhere hidden in the relation between the original chemical energy and the heat resulting therefrom on combustion. Between the unknown temperature and the still less known but nevertheless existing chemical potential there must exist a mutual relation according to which the height of the one depends on the height of the other.

Between the radiated light of a glowing body and its temperature such a relation is known under the name of Stefan's law. If one knows the radiation of a glowing body, *e.g.* the sun, its temperature can be calculated therefrom. Of the sun, only the radiation is known, and from that the unknown temperature at the sun's surface is calculated at 5,500 to 6,780 degrees Celsius. By the same method the temperature of the positive zone of a normally burning arc-lamp was found to be 4,200 degrees Celsius. There is nothing to prevent us assuming that an appropriately constructed burning glass interposed between sun and earth—focus on the earth's surface—would enable the sunlight to heat a piece of earth to the temperature of the sun. The temperature of the sun lies hidden in its radiation, in the sunlight, as light potential. If the temperature of the sun should alter, the light potential would alter in the like sense. But while the temperature of a quantity of heat dissipating itself in space diminishes with the dissipation, the light potential of the sunlight is maintained independent of the dissipation of the light, it is—only by means of the scientific expression can I say it so as not to

**Pirquet*, System of Nutrition, Berlin, Julius Springer. (A nem is the nutritive value of one gram of milk.—*Ed.*)

be misunderstood—a function of the wave-length of the light-rays, and these wave-lengths are unaltered by the dissipation of the light.

Thus, then, from these considerations we have suddenly gained a measurement conception of the light energy consumed in the formation of food energy, a conception, it is true, which can be valued only as raw material from which the true structure must be worked out ; and yet a conception which hitherto we have altogether lacked, and at the same time a new base for approaching nearer to the real chemical food potential.

The sunlight potential which performs the work when energy is stored up in the plant corresponds to a temperature (in round figures) of 6,000 degrees Celsius. The importance which this approximate measurement of the light potential has for me will be the more readily apparent to you the better you remember my reasoning of yesterday which culminated in showing that between chemical energy as it is stored up in the plant, and sunlight energy, there must exist a yet unfathomed kinship in nature, if not indeed identity, so that that which nourishes must be the solar energy itself organised by life.

Thus the central question as to the relation between light energy and chemical energy draws attention ever more urgently to itself. And this question we must now consider more in detail for its solution will at some future day decide the nutrition question so far as it is purely a question of natural science. But you will see that even in the present state of scientific knowledge the answer is capable of opening up new undreamed-of prospects.

II

THE SPECTRA OF LIGHT

If one heats a small crystal of common salt in a colourless gas-flame, the flame is coloured a fine yellow. This happens because the sodium of the salt is vaporised in the heat of the flame, and, as glowing gas, sends out yellow light. Between sodium and yellow light there must therefore be some close connection. If one allows this yellow sodium light to enter, through a narrow slit, a tube at the end of which there is a glass prism, the light rays are diverted by the prism into another direction, so that the eye of the observer looking through another tube in the new direction at the crystal, sees in a quite definite position a brightly shining yellow double line.

If instead of the sodium one takes potassium for this experiment, one sees a bright red line and a faint violet line, but these lines occupy positions quite different from that of the yellow lines of sodium. Lithium gives a strong red and a faint yellow line, and again these lines appear in positions other than those of sodium and potassium. Rubidium gives two violet and two red lines, caesium two dark-blue, thallium a green, hydrogen a red, a green, a dark-blue and two violet lines. If we proceed to test in this way the glowing gases of all known substances it appears that each has its special light lines—also called its special *line spectrum*.

From this you see at once that each of the 92 elements and also each of their vaporisable compounds emits a special characteristic light which is broken up by a spectroscope (Fig. 4) into a series of lines. Since the bending (refraction) of a ray of

light is the stronger the shorter its wave-length and the more rapid its rate of oscillation, one can calculate the wave-length and the rate of oscillation of

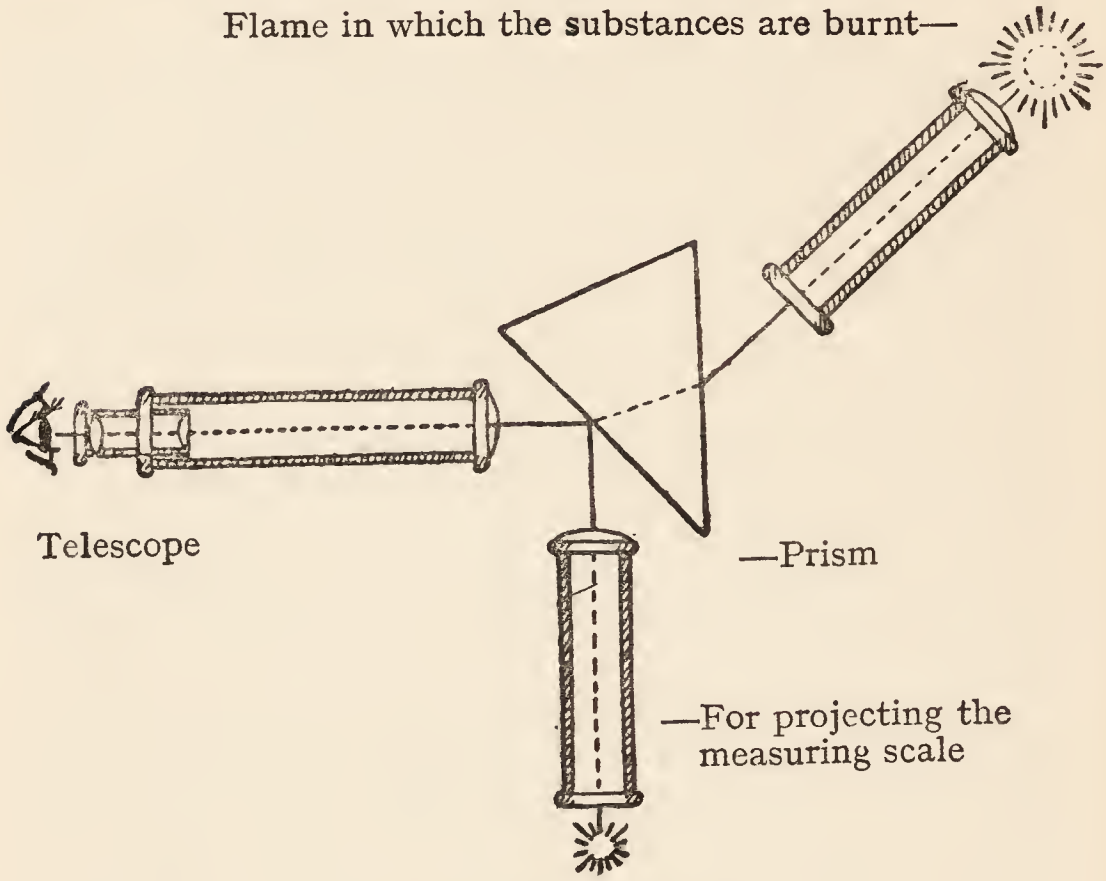


FIG. 4. Spectroscope

the particular ray of light from the position where the lines are seen on a measuring-scale.

As first relation between the chemical substances and light, it appears then that to each particular substance belongs a definite-coloured light of definite wave-length and rate of oscillation.

Now what would be visible in the spectroscope if one could simultaneously vaporise and bring to incandescence all the 92 elements ?

The lines of coloured light would appear side by side from darkest red through light red, orange,

yellow, green, blue to the darkest violet. The series of lines of coloured light would appear before the astonished eye like the cross-section of a rainbow.

Since you have certainly all enjoyed the majesty of a rainbow you are acquainted with the sequence of colours just named, and you know too that the refraction of the sunlight through the rain-drops, as through glass prisms, is the cause of this wonderful play of colours. White sunlight, then, is a complete mixture of all these coloured rays. Accordingly, if one admits through the slit of the spectroscope a narrow band of sunlight, the observer through the telescope sees a broad glowing rainbow-coloured ribbon, the *sun spectrum*. By means of the photographic plate it has been discovered that the visible sun spectrum is continued left and right into the dark, beyond the red into the ultra-red and beyond the violet into the ultra-violet.

Fig. 5. Spectrum of the Sun

When this sun spectrum was more closely observed with perfected apparatus, it appeared that throughout the whole breadth of the brightly glowing colours are scattered fine dark vertical lines, always grouped in the same way and always occupying the same position —Fraunhofer's lines (see Fig. 5). Their position exactly corresponds to the position of the coloured light lines of a number of the vaporised incandescent elements in the emission spectra of which you have just heard. Thus one finds repeated in the sun spectrum the double line of sodium, but dark instead of bright yellow.

These Fraunhofer lines found a remarkable explanation. For if through a glowing gasified element whose line spectrum one is observing through the spectroscope, one passes white light, the coloured lines are changed into dark lines distributed among the bright coloured spectrum of the white light. The glowing gas, then, has deprived the white light of precisely those rays which it itself radiates, it has *absorbed* these particular rays. Hence a spectrum with Fraunhofer lines is called an absorption spectrum. And such a spectrum is the sun spectrum. The glowing sun, emitting white light, is surrounded by a mantle of glowing gases which absorb the rays peculiar to them. From the Fraunhofer lines, then, could he determined which elements form the gas mantle of the sun ; indeed through hitherto unknown dark lines in the sun spectrum new elements such as Helium have been discovered.

Thus the atom of the glowing gas absorbs from white light precisely those rays which, when it has become self-luminous, it emits, and moreover it thereby extinguishes its own light. Therefore the wave-length and vibration-rate of the absorbed ray must encounter in the interior of the atom closely related recipients, somewhat in the same way in which that particular note which thrills through the air is caught up only by that particular tuning-fork which on being struck sends it forth, while no other note is capable of setting this tuning-fork in vibration.

Now an atom, as its line spectrum shows, emits not only one but a number of different wave-lengths which distribute themselves over the whole length of the spectrum from the ultra-red to (and into) the ultra-violet, and appear as light-lines in characteristic grouping, and for every element in a different grouping, the number of groupings increasing

with the atomic weight. It appears, then, that each element must have in its atom a definite number of different " tuning-forks."

As sounds and harmonic chords are composed of related tones and overtones—owing to the mathematical relations of the rates of vibration of the sound waves—so the light radiations of the atoms would be harmonic light chords—series of wave-lengths mathematically attuned to each other, which the ear does not hear, but the eye sees. And within the atoms there would be—like tuning-forks—vastly more quickly vibrating unknown instruments in well-ordered series. And in fact the Swiss physicist Balmer has shown that for the spectrum lines belonging to an atom a mathematical harmony formula may be established, so that every element may be described by its Balmer formula.

The impression made by these wonderful relations between light and substance is strengthened by the further discovery that not only the 92 elements but also all compounds radiate such line spectra.

The whole material world seems to resolve itself into vibrating harmonies when one tests it with regard to its relation to light ; the stronger therefore grows the desire to look into the interior of the atom, in order to become acquainted with the vibrating light instruments which we assume to exist there ; for in these light-radiating instruments must not only the relation between light and chemical energy but the nature of chemical energy itself find its solution.

And this is precisely what we are seeking, for this so carefully enshrouded nature of chemical energy must first become known before the human mind can succeed in finally grasping *the nourishing*, so that the bewildering confusion of opinions and theories which has caused so much mischief must finally capitulate.

III

INTO THE INTERIOR OF THE ATOMS

The atoms are the smallest particles into which it is possible with all the means, especially the chemical means, at our command, to divide the matter known in our world—that is to say all solid, liquid and gaseous substances, platinum, gold, granite and rock-crystal, oil and water, air and ethereal perfumes, but also every portion of the vegetable and animal world together with the material substance of the human body. This world of bodies thus proved to be composed and built up of 92 elements and, since the atom is the smallest particle of an element, there are also 92 different kinds of atoms.

These atoms are inconceivably small. It would be useless to attempt to give you an idea of their minuteness. But each of the 92 atoms has its quite definite qualities by which it is sharply distinguished from the other 91. It has its atomic weight, its selective chemical affinity and valency, its electric and magnetic powers; and it has its special line spectrum.

At the time when, as a grammar-school boy, I became acquainted with the facts of chemistry, it was always in my mind that it had not been possible to show that these 92 elements (at that time only about 70 were known) were built up from a single primeval substance. I was told that it was not allowed to indulge in such fancies, science had shown quite clearly that a further division was unthinkable. After this I no longer ventured to speak to anybody about this necessary demand of my mind.—To-day the case has altered.

After Mendelejew, Meyer and Crookes had ar-

ranged the elements in a system* so that they exhibited a striking periodicity of properties, after—to put it briefly—there had everywhere grown up a tense expectation of the solution which seemed close at hand and yet not within grasp, suddenly into this tense atmosphere there burst like a bomb the news that Mme. Curie in Paris had discovered a new element, radium, which continuously emitted light, Röntgen rays and electricity, and decomposed withal into other elements, *e.g.* helium, and finally lead. The indivisible, the atom, *had divided!* The unchangeable had changed.

This discovery was followed by feverish activity on the part of the experts, and this has brought about a result which by its simplicity and magnitude is worthy of the interest of all thinking men.

Let me now impart to you as briefly as possible that part of this result which is absolutely necessary for our purpose.

THE ATOMS ARE ELECTRICAL STRUCTURES. The ultimate particles of electricity have already long been known as positive and negative *electrons*. The mass of a negative electron is about 2,000 times less than that of the smallest and lightest atom, the atom of hydrogen whose atomic weight is 1. The positive electron is even smaller than the negative electron. The mass of these electrons is only an apparent mass, simulated by their extremely rapid motion whose velocity attains that of light, 300,000 kilometres a second. In these smallest particles of matter we have then no longer anything tangibly solid, anything really substantial, material, but only negative or positive charges of so many units of electricity, *i.e.* a positive or negative "quantum" of charge of electro-magnetic energy.

On the basis of the discoveries of the English

*Newlands was the first to attempt this.—*Ed.*

savant, Rutherford, the Dane, Niels Bohr, developed his wonderful theory of the atomic model wherein is represented the structure of the atom out of electrons. From this it appears that in the atom is repeated what we observe in the universe in the heavenly bodies. As *e.g.* the sun with its planets is a planetary system in which all the planets revolve at different distances from the sun as centre, so is an atom an electron system in which the negative electrons revolve with immense velocity at different distances round a central point formed by the positive electrons. This you will more easily grasp with the help of a few diagrams.

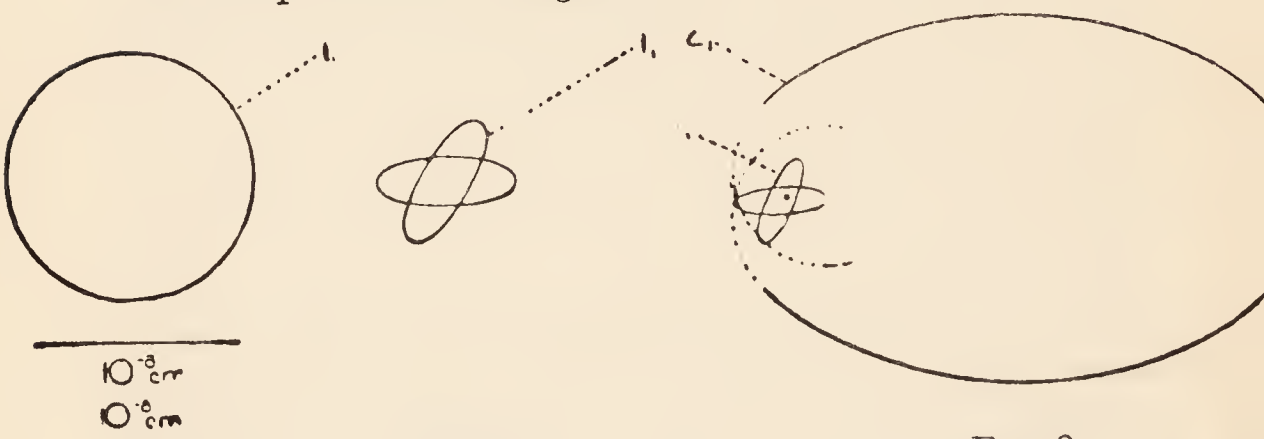


FIG. 6. Hydrogen.

FIG. 7. Lithium.

FIG. 8. Helium.

The first drawing (Fig. 6) shows how a hydrogen atom, the smallest and lightest of all atoms, is composed of two electrons, a positive and a negative. The negative electron is kept at a certain distance by the attractive force of the positive, while the momentum of its revolution prevents its rushing into the middle point.

In the second drawing (Fig. 7) you see an atom whose nucleus is formed of two positive electrons, round which revolve two negative electrons in different planes but at the same distance. This is the helium atom, the second in the natural system of the elements, of atomic weight 4.

The third element, with the atomic weight 7, lithium, has three positive electrons in the nucleus, and, revolving round it, three negative electrons, of which the third revolves in an elliptical orbit with continuous displacement and at a greater distance.

You will have noticed that :

—the first element has 1 positive and 1 negative electron in the atom. Atomic weight = 1

—the second element has 2 positive and 2 negative electrons in the atom. Atomic weight = 4.

—the third element has 3 positive and 3 negative electrons in the atom. Atomic weight = 7.

In the same way the numbers of electrons increase further in the series of the elements up to the 92nd., uranium, which has 92 positive and 92 negative electrons in the atomic structure. The numbers which denote the place in the series are always the same as the number of positive electrons in the nucleus, for which reason they are called ordinal numbers.

The central sun, the atom-nucleus, has for each successive element one more positive electron, but the number of the satellites revolving round the nucleus increases equally. Soon, however, the additional negative electrons have no more room at the same distance from the nucleus, and they are held at a second, greater distance. After the second distance has received its allotted number of revolving negative elements, which occurs after 8 electrons, the next following electron is held revolving at a greater distance, and so it continues with the formation of ever new revolving distances until with the last element all the 92 negative electrons have received their right places, in which they would to

all eternity revolve round their nucleus if no event should happen capable of disturbing this peace of God.

If now all the points touched by the electrons revolving at a certain distance from the nucleus are arranged schematically, they sometimes form a sort of spherical shell round the nucleus, just as the path of the earth round the sun forms a circle, or more correctly an ellipse. The paths of revolution have, according to the shell to which they belong, a quite definite energy value. This comes from the fact that it requires a strictly measurable "energy quantum" to transfer an electron from an inner to an outer path, or conversely that a quite definite energy quantum becomes free when an electron is projected from an outer path to an inner path. Therefore the paths of revolution of the negative electrons are called also the quanta paths, and these quanta paths receive according to the sphere to which they belong a quanta numeral with which their energy value is indicated. The electrons of the inmost path have the quanta numeral 1, those of the second path the quanta numeral 2 and so on; so that there are even and uneven quanta numerals.

Will you now look more closely at the "drawing from life," by Niels Bohr, of the radium atom (number in the series, 88), (Fig. 9). Here the electron paths with uneven quanta numeral are shown by continuous lines, those with even quanta numeral by dotted lines. Although in this drawing sometimes only a single loop of the path is shown, it yet gives an idea of the marvellous structure of this atom. When your eye has taken in the picture, try with eyes closed to set the whole structure in motion internally, on every loop an electron revolving with the velocity of light. We must next extend the same idea to every substance in the world, to the

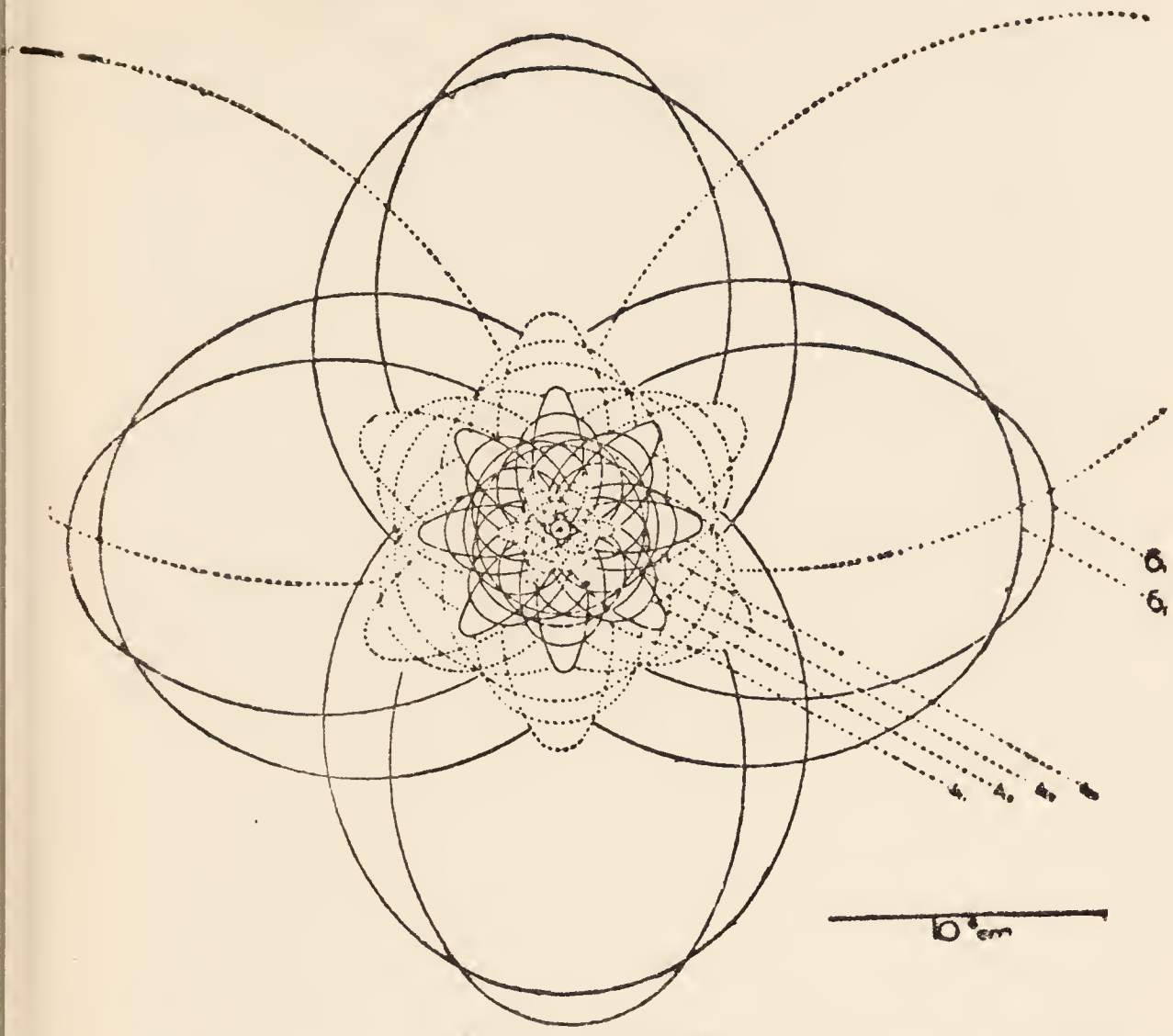


Fig. 9. Radium (88)

Preliminary, schematic representation of the internal atomic structure of certain elements according to Niels Bohr.

Figures 6 to 9 were taken, with kind permission of the publishers, from a Danish popular book on the Bohr theory (Helge Holst and H. A. Kramers : *Bohr's Atom Theory*, Gyldendals, Copenhagen, 1922). As we were not able to use colours we have in the first three atomic figures disregarded the distinctions between the electron paths shown in the original—odd cardinal quanta-number black, even cardinal quanta-number red, and in the Radium figure we have substituted dotted lines for the red lines (=even cardinal quanta-number).

But the wonderful plan of the electron paths of Radium which is thus revealed to us will have value and meaning only for him who uses these circles and ellipses in order to picture to himself on each of them a negative electron circulating with immense velocity round the central point, a circulation surpassing all conception, ordered, beautiful, rhythmic, of electric energy-points, a minute world of electric and magnetic influences, whose totality is perceived by our senses as hard metallic masses, when billions of such atoms, united to a particle, become perceptible.

In Radium these atom-systems are exposed in regular sequence to an internal explosion, whereby single electrons and helium nuclei are hurled forth like bullets with immense velocity and simultaneously produce Röntgen rays of the greatest power by colliding with neighbouring atoms.

gaseous, the liquid, the solid; to gold, platinum diamond; to vegetable and to animal substance, and finally to all the substances of our human body, to the eye, to the blood and ultimately also to the delicate nerve substance which builds up the brain. This whole physical All is a well-ordered electron-structure in oscillating, revolving motion, no longer substance but charges of electric quanta moving with a velocity which approaches that of light.

What might here be said of the atoms of the elements holds good of course also of the molecules of compounds, only that with the combination of atoms to molecules yet new possibilities occur for the formation of quanta paths. You will readily see what importance the discovery of the quanta paths possesses for the relation we are seeking between light and chemical energy.

IV

IDENTITY OF LIGHT AND CHEMICAL ENERGY

I said just now that it requires a definite energy quantum to shift a negative electron from an inner to an outer path and that in the same way a definite energy quantum becomes free when an electron shifts from an outer to an inner path. Now this energy quantum is a ray of light of a certain wave-length in the case of outer circles, a Röntgen ray in the case of transition from the first to the second quanta path or the reverse. If from any cause—attraction by the positive nucleus, impulse from without due to bombarding molecules (heat motion of the molecules), bombarding atoms or electrons—a negative electron is brought from an outer quanta path to an inner, a

ray of light—the freed energy quantum—flashes instantaneously into the outer world. The wave-length of this light-ray depends on the alteration of the distance from the nucleus, *i.e.* on the quanta path. Also there exists a correspondence between the rate of vibration (wave-frequency) of the light-ray and the circulation numeral of the electron. It follows that the atoms of a heated and gasified element can emit only a limited number of wave-lengths, corresponding to the possible alterations in the quanta paths when the atoms collide ; and herewith the explanation of the line-spectra is at last found. Those vibration-instruments—" tuning-forks "—which we assumed in the interior of the atom are the electrons revolving in quanta paths. The possible alterations of the quanta paths are different for each element and also for each compound. Hence each element and each compound has its one characteristic spectrum. Every light-ray represents with wave-length and vibration-number a quite definite quantum of electro-magnetic energy and this quantum is exactly equivalent to the quantum of atom-energy or of compound-energy which became free on alteration of the quanta path in the interior of the atom or compound. This internal energy quantum is also electro-magnetic energy. Both quanta, that of the light-ray and the internal atom quantum, are one and the same thing, seen now from without and again from within, now light and again chemical energy.

And herewith the identity of light and chemical energy in principle has become a proved and incontestable fact. But it is equally clear that a difference in chemical energy corresponds down to the smallest detail with the difference in the light-rays, and that a multiplicity of chemical energy quanta corresponds to the multiplicity of the light-rays.

This identity of light and chemical energy is further confirmed if we consider the reverse process, the impact of a light ray upon an electron revolving within the interior of an atom. This process is indeed of central significance for the nutrition problem, since the food energy in the vegetable kingdom proceeds from sunlight, and hitherto nothing was known as to the transformation of light into chemical energy.

What happens when a light ray penetrates into the planetary system of an atom, and vanishes leaving no trace, is swallowed up, absorbed? The electron struck springs from its quanta path into an outer quanta path. It removes itself by a distance corresponding to the energy quantum of the light ray from the positive nucleus, and so revolves at a greater distance from its sun. Thereby the energy of the whole atom or molecule is increased by the energy of the light ray. The energy of the atom has assumed a new condition. If the nucleus, by its attractive power, succeeds in drawing the electron that has been torn away back into its former, nearer quanta path—re-establishing the former condition—then the light ray that had previously penetrated the atom speeds forth into the outer world with its former wave-length and frequency.

An example : If one exposes mercury-vapour at a temperature of 100 degrees Celsius to the monochromatic light of one of its spectrum lines, this light is absorbed. But after the exposure has ceased the mercury-vapour begins to glow with light of the same colour. This phenomenon is called the fluorescence of gases.

But if the electron, resisting the attractive power of the nucleus, persists in the more distant path, the atom in its condition of increased energy is ready, at the next opportunity that offers, to give up

its excess of energy. It is in an *excited state*, as it is called.

Will it now be difficult for you to apply in thought what you have just heard about *one* light ray and *one* atom to all the colours of the solar spectrum and to the myriads of atoms of the 15 elements and their compounds which participate in the storing up of sunlight in the plant? Scarcely, I think. You at once see the whole gamut of the different wave-lengths of the rays of sunlight pour themselves over this intimate world of the electron-systems, see how one wave-length here, another there, strikes upon an appropriate quanta path, how light ray after light ray vanishes, and how electron after electron springs into a more distant quanta path. Chemical energy is *being born*. Masses in excited states, of a multiplicity of internal energy-values equal to the magnificence of colour of the absorbed light rays, take the places of the rays that have been swallowed up, as if the light whirled and beat the atoms to ever looser, mistier masses, as the whisk does the cream. Thus out of sunlight originates the chemical energy with which the wisdom of life can fulfil its purposes and plans. And this energy is really light itself, is as full of colours, as full of quanta as the rainbow, as the solar spectrum, at least in proportion as the plant world absorbs the sunlight.

This chemical energy born of sunlight possesses, as every one can now realise, the same quanta structure as light in its gamut of wave-lengths revealed by the solar spectrum. With every displacement of an electron into an outer quanta path, that energy quantum which before quivered through the ether as light ray of a certain wave-length, is retained in the electron world of atoms and molecules. If the right opportunity comes the electron will again spring back into the nearer

quanta path and the energy quantum of the former light ray will again become free. It may be that this liberation takes place in the fibrils of the living muscle, where it becomes a quite definite quantum of muscular energy, or in the brain cell, where there are formed out of it the so immeasurably finely differentiated nerve forces which our consciousness perceives as sensations, feelings, emotions.

There is then a quanta series of minutest quantities of energy which persist as such and are organised after the fashion of the scale of rainbow colours; and of these life disposes in building living substance, in building proteids, fats, carbohydrates and vitamins, in building plant-organs: leaves, roots, bulbs fruits and seeds. Ay, we may here imagine something deeper: Since every plant has its particular green and its particular flower-colours, it selects from the solar spectrum according to the laws of absorption those wave-lengths which seem suited to its purposes. Connected with this doubtless are the peculiarities of its substances, the material composition—so to speak, its recipe—which, when we eat it, so strongly affects our organs of taste.

It is even not impossible that the forms of the plant-organs in their amazing multiplicity will some day reveal themselves as an internally conditioned result—a function—of the selected spectrum, of the special kitchen recipe of each kind of plant. A fruit would then be a whole symphony of chemical energy quanta, with counterpoint, harmony and melody according to a series of themes played by the creative spirit. And the like might of course be said of every other organ of the plant world.

This would explain why we cannot nourish ourselves with proteid, fat, carbohydrates and the necessary minerals artificially assorted, why there will never be a condensed food prepared by the

chemist, and pressed into pills. This would also explain why a diet of grain without the husks causes grave nutrition-disturbances, while corn with the husks maintains health. The plant organ built up by nature must be accounted then *the integral unit of the nutritive principle.* Indivisible, because division would violate the suggested laws of harmony of the chemical energies organised by life.

This attempt at a scientific vision may be bold but it is not unjustified. No one has yet attempted to reveal the significance and the meaning of the food ready made by nature. But shall we ever be able to attain to an adequate nutrition theory without this significance and this meaning ? Having regard especially to the tasks of the physicians, it seems to me that the truer method would be here also to seek the meaning and the wisdom of the Creator rather than to treat with complete indifference the integral values of foods.

V

NUTRITION-POTENTIAL

In our discussion to-day we have without noticing it approached nearer to the hidden content of the conception which I had already mentioned : the nutrition-potential. The nature of the chemical energy of food has now been brought within the grasp of the human understanding. It consists—I do not know how otherwise to express this—of symphonies of mathematically graded energy quanta which are completely identical with the quanta of the solar spectrum. This of course holds only for vegetarian food in its natural state. But of the solar spectrum we know that it is equivalent to the

temperature (heat-potential) of approximately 6,000 degrees Celsius. We may say then that the equivalent chemical quanta spectrum of food energy is also at the level of this temperature. With the further investigation of our problem this may undergo all sorts of corrections, but the principle of the equivalence will stand any test.

It is surely superfluous for me here to hark back once more to the combustion heat of the food, calculated in calories, and to point out that the calorie values tell us simply nothing about all these vitally important values of chemical nutritive energy. And now at last will this portentous fact receive recognition in the medical camp? To me it is inconceivable how even the physiologist Höber, and that clever physician of Berne, Christen, who unfortunately died before his time, could declare chemical potential and number of calories to be one and the same.

CALORIES ARE THE MEASURE OF A QUANTITY OF HEAT, NOTHING MORE. Heat is *molecular motion*, the quicker the higher the temperature. But, however great may be this velocity, it is many times less than the velocity of the electrons in the interior of the atom or than the velocity of the light rays. All energies can be completely converted into heat but never heat completely into the other energies. Chemical energy is *electronic motion* in the interior of the atoms and molecules, is electro-magnetic tension—that is, something fundamentally and essentially different from heat. A number of calories may result from very various chemical energies—one may burn alcohol, carbon, sulphur, phosphorus—who shall detect in the calories whence they originate, what is the value and significance of their source?

As they may have an origin of greatly varying

value, so have calories a greatly varying utility. But here I am back again at the Second Law. You only need to insert here what I said about that. I will not repeat it. Only to this extent; with the nutrition-potential built up by life out of sunlight—corresponding to 6,000 degrees Celsius—we have found the highest level of chemical nutritive energy. Now let any one prove to me that this level *does not fall* in the many vicissitudes of the nutritive material from the plant through the animal body, the process of dying, fermenting, decaying and cooking. Let any one prove to me that the multiform mutilations and demolitions which in these processes the quanta symphonies of chemical energy—composed and organised by life—undergo are of no account for nutrition, that the number of calories is all that matters.

If this counter-evidence should prevail, all my trouble would have been in vain. It would mean that I had simply erred and gone astray. Up to now however this counter-evidence has miserably failed, and—we shall have to wait a long long time for its success.

During the last twenty-five years every essential step forward of the science of nutrition has only aggravated the difficulties for that counter-evidence and brought to light new supports for my standpoint. The most brilliant confirmations, however, come to me in the daily experiences of life, but of these I cannot speak in these lectures.

VI

FINAL OBSERVATIONS

This completely new theory of the peculiarity and the essence of that chemical energy which underlies

our nutrition and our life, of its identity with sunlight, of the energy quanta symphonies as the real nutrition potential, should receive the most careful attention of scientific men, especially of physicists and physiologists, because it requires thorough testing with expert knowledge and the great equipment of the scientific laboratories, and because it is capable of great development and elaboration. I am only a physician who is compelled to work with very limited means, who lacks the higher mathematics, who has been able to penetrate only partially and haltingly into the wonderful achievements of atomic physics and of spectrum analysis. But this should be remembered not merely as an excuse for contemptuously ignoring my ideas but as an incitement to widen the breach which I have made in the thick wall of prejudice and to mature the theory. Such action is not to be expected from inferior natures ; for, as to these, the physicist will be afraid of the physiologist, the physiologist of the physicist and both of the clinic and ultimately of the whole dense mass of mankind. A glass of beer is a glass of beer, and a beefsteak a beefsteak, and brandy with eggs strengthens the sick. Who will attempt to shake such immovable truths ?

Four years ago in Paris I entered the night train for Zürich at about 9 o'clock in the evening and took my seat in a compartment which at first remained quite empty. At the instant of starting a gentleman jumps into the carriage, and gives me courteous greeting. " Will you talk in French, German, English or Russian ?" This is certainly no Frenchman, I say to myself. Presently we find ourselves in eager conversation. He had formerly been Professor of physics at the University of Petersburg. First he told me the wonderful story of his life before and after the war and the revolution. Poverty,

wealth and again poverty, luxury and privation, had succeeded each other. (Now he was occupied with the American armoured car encampments). In this way I soon got to know my lively travelling companion better than all my comrades of college or camp ; and presently we began to speak of physics. He told me that he was interested above all in the sun's rays. " I have occupied years of my life with these ether-vibrations, and therein I have discovered the deepest secrets of the world and many miracles of life." Ladies, you may imagine how deeply this man interested me, and that our conversation never slackened until, after four hours journey, he left the train at Troyes.

I too have spoken to you to-day of nothing but sun-rays, electron quanta and wave-lengths. Unfortunately I could not make my discourse so entertaining as did the Russian professor. It must have been a troublesome task for you to follow me, and it may have seemed to you that we were getting too far away from our subject, the theory of nutrition. But your attention and your interest have made my task easier, and for this my best thanks are due to you.

Now you see that we have always had our subject closely in view. A theory, simple but largely planned, now stands in clear outline before our eyes. Not only the plant world lives on sunlight, but the animal too, the human being too. That which nourishes is the sun's energy organised in the plant by life. The whole life of our organism, of our living body is a field of action of the sun's energy, a field of action well-directed by hidden wisdom. Food is organised solar energy. The light value of the food is at the same time its nutritive value.

SOLAR RADIATION AND HUMAN LIFE ARE MOST INTIMATELY CONNECTED. Life is concerned with

light energy and its wealth of colours, not with proteids, carbohydrates and fats, not with nitrogen, hydrogen, carbon, not with calories.

Sunlight gives to life its richly-woven garment and its working power. Our body, the matter of which we are composed, resolves itself into sunlight, an intangible, iridescent, flashing and yet so well ordered revolution of electrons in the quanta paths equivalent to the absorbed light-rays. No body—a play of electrons in a mighty stream issuing from the sun, ceaselessly rushing through our nature and existence. And ruling over this as superior powers the mind, the ego, the spirit. Such is the order and the subordination of the nutrition energy process in the nature and existence of man.

* * * * *

And when they awoke from their quest for the Blue Bird, everything had become so much more beautiful, so different, so new !

FOURTH LECTURE

Klingsor's enchanted garden and the rediscovered Grail—Relations between the food and the mental life—Dimly lighted food a barricade against the Spirit—Classification of foods into three categories.

You are no doubt familiar with the legend of King Arthur and the Round Table. In this legend we are told of two worlds fundamentally opposed : one the illusory world of Klingsor, the enchanter, the other the world of the Holy Grail. While in the first the human being is seduced into alluring pleasures, thus falling under the spell of the enchanter and finally perishing in disease and suffering, in the world of the Grail he finds the revelation of the meaning of life, healing for the wounds of life, the salvation of his soul, release and freedom from all anxiety about life and from need. Life leads everyone into Klingsor's enchanted garden, but the way to the Grail is discovered only by the elect who sees through Klingsor's enticements and of his own free will turns his back upon them.

It is surely quite superfluous to say that this legend represents an eternal vital truth. There is no human being who escapes being tempted by the world of illusion. When from his childhood he has felt the lack of love, when he believes himself alone and forsaken, when he feels too weak to face the demands of life, when he is secretly devoured by the fear of life, then he is tempted to seek cheaper love, borrowed and stolen strength, artificial courage, the comfort of a deceptive self-confidence ; and only too

easily he finds the way to Klingsor's realm. In other domains this need, this danger and this temptation are to some extent recognised, but far too little in the domain of nutrition where we have to take into account not only self-preservation with all the worries that beset it, but all the other unsatisfied instincts. The influence of these powers of darkness on man's nutrition grows with the diminution of self-control, compulsory or voluntary. But how far they have been able to falsify the very nature and purity of our choice of foods, and even the formation of our theories of nutrition, this will never be understood until the principles of human nutrition are recognised by us and help us to distinguish the true from the false.

This much, however, may be said at once : There is a Klingsor nutrition which entices men with deceptive values, brings them under its spell and then delivers them over to suffering and disease. And equally there is nutrition according to the Holy Grail, which gives new strength, frees from sufferings and corresponds to the meaning of life. This nutrition we began to recognise at that moment in our discussion of yesterday when the nourishing principle became visible to us.

To-day we wish to draw a new picture of nutrition so that we may know what is the nature and composition of the purest and best human food. No one needs to be surprised if it is altogether different from the generally customary diet of our people and especially of the educated and well-to-do, unless indeed he is ignorant of the fact that the latter causes so many grave illnesses, a fact which has long and often been pointed out by all the experts.

If then the difficulties occur to you which everywhere await any change of diet, I beg you to remember that a decisive internal act of repentance—if I

may say so, a Parzifal event—must take place before it will become possible for man to save himself from Klingsor's magic power. The meaning of the legend is living and valid to-day as of yore, for the individual as for whole peoples.

I

The relations between the life-awaking light of our sun and the electron-worlds of the atoms and molecules unmasked for us at last the so mysterious secret of nutritive energy. Nutritive energy is indeed chemical energy, but an energy distinguished by unsuspected qualities, an unique energy organised by life. We suspect already that the elements of which the living substance is built up are selected and used according to the different nature of their atomic structure and the quanta possibilities of their electron-paths. Here nothing is left to chance, everything is wise mathematics. Some day we shall be able to recognise, from the atomic structure, which light chords can be transferred into life by the sulphur atom, and which by the iron, the phosphorus, the nitrogen atom. At the same time it will be seen how by the choice of the elements the electropositive and the electronegative and also the magnetic forces are opposed to each other in measured tensions. Finally it will be more and more understood that only the whole fruit, the whole nut, the whole grain of corn or the whole plant-organ (leaf, bulb, etc.) can form a valid unit of nutrition, a nutrition-integral.

This nutrition-unit—fruit, nut, bulb as store of food for shoots or seedlings, green leaves as organs in which takes place the whole elaboration of chemical energy from sunlight, grain of corn as

nutrition-unit for the sprout—is at the same time *a life-unit* also. When in springtime the seed-corn or the potato begins to sprout in the ground, the new plant at first grows without light to a respectable size using its allotted store of energy, then pushes its way out of the earth into the light; and only now does the sunlight take over the feeding of the growing life. Evidently then during the sunless period the food store united with the germ as seed or fruit fulfils all the tasks and purposes which afterwards are assigned to the sunlight. Who will explain this phenomenon better than it is explained by the identity which I have shown to exist of sunlight and nutritive energy as it is created by life in the plant in primeval freshness and validity? But this too I ask: Who has even thought it worthy of remark that hitherto nutrition has been discussed and taught without noticing that this profound identity between nutritive energy and sunlight exists, that heat calories and nutritive energy have unhesitatingly—what "scientific" naïveté—been accounted identical? As if one could take sunlight to be the same as heat! Pray, then, take the seedling out of the seed-corn and nourish it with—calories! If a mother says that her child has worms because it has eaten too much bread, one laughs good-humouredly at this ignorance. Worms from bread—spontaneous generation!—superstition! *Omne vivum ex ovo*—the worm can come only from a worm's egg. The time will come when greater laughter will greet the calories superstition.

Nutrition energy is chemical energy, but it is comparable with no other chemical energy, is replaceable by no other chemical energy. It is a chemical energy organised by a higher wisdom according to scarcely dreamt of measures and values; an energy of which moreover one may say

that it stands in a relation of equivalence to the heat potential of the sun, *i.e.*, to the temperature of about 6,000 degrees Celsius.

For this reason it is impossible to sustain life with coal, saltpetre, gunpowder or dynamite. For this reason it is right, it is highest and best, to seek human food *at its source*, where the nutritive energy has its origin in sunlight and in life, in the plants, in the primeval units of nutrition.

Here one will be tempted to think that there are also other nutrition units of animal origin, such as *e.g.* eggs and milk. The hen's egg also is a complete synthesis of food material for the first period of growth of a living being. But try to feed a human being on hen's eggs alone, or even with a diet in which hen's eggs form the chief constituent. This person will very soon fall ill. The digestive organs will refuse to act, the kidneys will excrete albumen, and will presently become inflamed. And if you do not soon abandon your experiment, the grave injury to his organism will cost him his life. Why?—Because the wisdom of life designed the food material of the egg only for a life-stage of the embryo chicken, characterised by certain conditions, for a stage of most rapid growth without motion. For milk, Bunge has proved this special and careful design of nature. He has shown that the composition of the milk of the various species of mammals, in particular the albumen-content, stands in a certain relation to the rate of growth of the particular suckling. Moreover milk, as you already know lacks iron, which the new-born animal brings with it into the world in quantity sufficient to last for the nursing period. Hence a person whom you try to nourish on milk alone (or even mostly, *e.g.* on milk and white bread) will also sicken, will suffer from ever-increasing poverty of the blood, waste away and so die.

The injuries which arise through the policy of boiling the milk, through the destruction of the vitamins, so that in the most extreme cases Barlow's disease results, all this I have not taken into account. But what I wish you to notice with regard to milk is the dependence of this food upon the source from which the mother gets its food. Milk has different nutritive results according as the cow is fed on green fodder or dry fodder. With green fodder the nutritive result is better, for simply by drying the grass the nature of the original nutritive energy is degraded. The vitamins are said to be diminished.

But what are the vitamins? Something intangible, something that exists, that acts, and yet something that no one has been able to find. They are still *unknown substances!* For example, 200 grams of dried yolk of egg were extracted with 400 cubic centimetres of water, and the water evaporated off. The water-soluble vitamins should now be present in the 4.5 grams of dry residue. The chemical analyses of this dry residue showed nothing but inorganic salts. At first then, these inorganic salts had been contained in the yolk in a fine, regulated state of division mixed with all the other material. And we know that their molecules had there possessed electrons banished into outer paths, that they were there in another, an *excited* state, which again was connected with the excited states of the organic molecules, all this in exact proportion with the captured solar spectrum. Precisely herein lay the glory, the wealth of colour of the nourishing principle. Hence we are justified in asking: are these vainly sought, still unknown substances, perhaps spectral proportions of excited molecular states? Is it for this reason that they are undiscoverable by chemical analysis? According to all that I know of the matter, this seems to me the most probable.

This much is certain that the excited states of the molecules, either of themselves or at the slightest impulse, give up the energy quanta and pass again into the stable permanent states of the neutral molecules, thereby losing their specific nutritive action. In this way the sensitiveness and the ready destructibility of the vitamins would be explained without difficulty.

And with the help of this conception of the vitamins the relation of animal to vegetable food would be more readily understood. Since the so-called vitamins originate only in the vegetable kingdom,* and yet are contained in cod-liver oil, milk and eggs, animal products, it will be seen that animal life is able to preserve, accumulate and use for its purposes the excited molecular states, so that in milk, in the egg, and stored in the liver and other organs, at least when living, they are always present in their original vegetable values, though mixed in the organs with other substances which as regards nutrition act rather as ballast. But from this it becomes comprehensible that milk, eggs and animal organs also possess nutritive value, and that beasts of prey, which swallow their victims alive and with the blood, can flourish on pure animal food.

But things become quite different when the animal is slaughtered, the blood removed, and when the cellular tissue and organs have passed through the *rigor mortis* and the boiling, roasting, smoking, or salting process. The well-known exothermic energy processes—pardon me if for the sake of brevity I do not explain these processes more particularly (see *Grundlagen der Ernährungstherapie* [Foundations of nutrition therapy])—which here come into play show that energy is being lost ; and

*According to more recent researches this is not the case. See *ante* p. 61, footnote. (*Ed.*)

where else can this expelled energy come from than from the most sensitive and at the same time for nutrition the most valuable energy-quanta-symphonies of the spectral nutrition energy formations ? Therefore the nutritive value of the flesh preparations consumed by the human being is utterly deficient and inadequate. It is true that decomposable masses which moreover are mixed with characteristic stimulants are subjected to human assimilation, and a feverish activity is started in the organs of digestion and assimilation which gives an illusory feeling of " strength " ; but this is only in small part nourishment, rather is it encumbrance and deception. If you feed a person on butcher's meat, fish and poultry only, he will succumb in a surprisingly short space of time to severe poisoning. I have somewhere read of Asiatic tribes who condemn their criminals to death by flesh. The condemned person receives either mutton only or veal only, and death is said to take place in 28 to 30 days.

With vegetable foods the case is altogether different. It is now proved that on a fruit and nut diet man can grow up flourish, perform full physical and mental work, and enjoy splendid health. Whole nations, *e.g.*, the Japanese, whose diet consists almost exclusively of vegetables, with unpolished rice as a basis, flourish and exhibit high physical, mental and moral virtues. In Japan, the man of the people—not forsooth the Europeanised Japanese physician—does not believe, as does the European, in the " strength " of flesh food. Accordingly the riksha-men, who had to run 25 miles a day, and whom Prof. Baelz of Tokio had offered meat for their extraordinary achievement, begged to be allowed to leave it, as it made them feel too tired and they could not run so well as before. From these facts we must conclude, whether we will or not, that

the energy relations of fresh vegetables correspond with the requirements of the human organism to a far greater extent than do the best animal foods such as milk and eggs; indeed that they alone completely meet the need.

This result completely corresponds with my theory of the essential nature of chemical nutritive energy and its original identity with sunlight. For our growth, preservation, health and work we need the whole splendour of the rainbow-colours, and moreover the quanta symphonies of the electron world organised by life with the atoms of the 15 biogenic elements. And in these symphonies the manifold as yet inconceivable claims of life are taken into account by an exalted wisdom.

II

For consider what unique achievements life has to perform. The light-organ of the fire-fly emits light without getting hot, without glowing, cold light. The electric fish produces in its electric organ free electricity with which it gives sparks and shocks. What marvellous knowledge must the creative wisdom of life have at its disposal in order that it may carry out such transformations of energy. Only the discoveries of the electronic structure of the atoms and of the connection between light rays and quanta paths promise to give us at last an insight into these marvels. Unique and superhuman are the tasks which the maintenance of life sets to nutritive energy, tasks which only a highly organised energy, an energy of quite immeasurable properties could fulfil. Above all is this true of the maintenance of human life wherein must be produced, besides heat, motion and chemical work, the finely graduated world of sensation and feeling. Even the

eye's sensation of light, relatively so simple, sets the task of distinguishing the different wave-lengths of the light-rays as colours, and of conducting them to the brain through the optic nerve as distinct sensations. Thus the organ of sight must dispose of as manifold gradations of the nerve-energy conducted by the optic nerve as the sunlight has gradations in its wave-lengths. This, too, becomes comprehensible only by the connections between light and chemical energy of living material, as I have described them to you.

If we go so far as to assume that the whole play and the whole power of the emotions from the most delicate impulses to the most violent outbreaks of love, fear and hate, joy, ecstasy, suffering and pain, take effect in the material world and penetrate to consciousness through mentally liberated energy-waves,—I myself cannot help assuming this —then we are face to face with achievements of the chemical energy working in life, which only a differentiation like that of sunlight and a marvellous organisation can bring about.

Music is rightly called the language of the human soul. Music works by means of notes, vibrations whose vibration-number determines the depth or height of the tone. The overtones accompanying the key-note have vibration-numbers which stand in a mathematical relation to that of the key-note. The overtones give the note its timbre, so that the ear recognises whether the note comes from the human voice, from the violin, the clarionet, the trumpet or a bell. By the sounding together of a number of different notes, chords result : concords, discords, major and minor chords. By the succession of notes and chords, melodies result, and by the introduction of time, rhythms. Now by means of this richly equipped and organised energy the genius

of the composer can manifest the inner world of his soul: gay joy of life and deepest tragedy, exalted happiness, liberation and salvation, and quivering pain, heroic grief, the profoundest religious emotion and mighty uplift to God. As I say this my consciousness runs through the familiar compositions, I hear Beethoven's *Eroika*, the Dead March, the only one which I could hear after the outbreak of the world-war; Handel's Aria, "I know that my Redeemer liveth," and his Hallelujah from *The Messiah*; the Death of Love from Wagner's *Tristan and Isolde*; the incomparable Requiem of Brahms, and then again the harsh piercing cry of distress of the Flying Dutchman. And now arises the memory of representation of cosmic emotions in the "Creation" of Haydn; "Let there be light, and there was light!" with the overpowering transition from C minor to C major.

Now, is music only the most suitable means of expression for representing the emotions, or is it more—an image, a reflection of the real energy processes in the domain of the mind by means of a certainly far coarser energy but yet of an energy similar in organisation and in nature? And if it is the latter, what could better instruct us as to the nature and action of the chemical energy working in life, as to its light-spectrum character, than music?

The achievements of energy manifested in the phenomena of life are so unlimited, universal, manifold, the apparatus, transformers and machines so fundamentally different from those which men construct for their technical uses of energy—so superior and simple, I may say—that only a driving energy of the marvellous nature of nutritive energy as I have tried to describe it to you can do justice to the whole phenomenon.

I think I have now helped you to realise that in the new theory an unsuspected and surprising kinship of the energy processes of life, the nutrition-energy and sunlight has become visible. There is only *one* great universal stream of sunlight which, caught by life in the plant, continues to vibrate in the electron formations of the plant organs until in the interior of the human organism it is transformed into the phenomena of external and internal consumption of energy. What our intellect sees in many essentially different disconnected fragments is but *One*: sunlight, primæval food, life phenomenon—sunlight serving in the realm of life, sunlight the driving force of our muscular motion, the power and the means of expression of our mind. Sunlight, food as it wells up from the primal spring of nature.

Everyone feels that we human beings live by the sun, but who knew until now, that fruits, nuts, green leaves and fleshy roots in the fresh state are the sunlight itself, prepared by a higher wisdom so that man even in periods poor in sunlight may live by the luminous, warm sun? Moleschott has said: "Tell me what thou eatest [*isst*] and I will tell thee what thou art [*bist*]." But who could imagine that the working of the mind depends to this extent on the nutritive energy, that dimly lighted food inevitably means a dim illumination of the mind.

I do not know whether it was with you as with me: when I was young it was with a sort of superior smile that I heard of the Buddhists in Asia who never slaughter animals and live on vegetable food only. "For religious reasons," it was stated, for "Thou shall not kill." "In the animals lived the reincarnated souls of dead human beings." I must confess to you that I have gradually arrived at the conviction that behind such impressive religious teachings for his people Buddha concealed much

deeper knowledge of the action of food and also of the human mind.

But the marvel—and certainly no "smiling" European will see it—the marvel is that several hundred million human beings influenced by Buddha actually renounced the use of animal food. And one must have already experienced what it means to set a man free from the lure of the flesh-pots.

We have penetrated far enough, as you see, to survey if only briefly the dependence of the bodily and mental life upon the nutritive energy. But our insight fails when it is a question of realising the influence of the choice of food, of the nature of the nutritive energy upon the most delicate and at the same time the most mysterious phenomenon of life—*the penetration of the spirit-principle into the life of the individual.*

I see your questioning eyes directed upon me: *What is that, the spirit-principle?* I answer you with another question: What is that which, hidden behind the phenomenon of life, knows and rules the electronic structure of the atoms and molecules and the inter-actions with light so accurately that, with this material and this driving power, it can build up living substance, and from this in ever rising organisation can finally form that marvellous work of art, a human being? What is that which created in the human being consciousness, perception and thought? What is that which raises the consciousness of one man so high above the consciousness of all others that he rises to be a leader of men, that a Lao-Tse, a Buddha, a Christ, or perhaps only a Francis of Assisi, a Goethe, a Lamartine, a Shelley appears before his fellow-men? What is it that acts in the weak so that they conquer brute force?

The answer I must leave to each one of you. For me it is the creative wisdom, the Spirit-Principle.

This principle acted not only once long ago at the Creation, but it continues to act eternally, it is acting now at this moment upon every living being, upon every one of us here. The organ through which it penetrates into the consciousness of the human being is the brain, at once the most delicate, most powerful and marvellous structure of living substance. Hidden in the spirit are the meaning, the goal and the sure guidance of life, but it depends on the condition of the brain how this meaning, this goal and this guidance are understood. When the Marconi apparatus on the Eiffel Tower sends forth its electric waves into the world it depends upon the receiving apparatus whether and how its language is understood. If the brain, the *receiving apparatus*, is in bad condition it will misunderstand the words of the soul. The realities of life will not receive due attention and their meaning will be falsified. The man goes wrong and goes wrong till he goes mad. With the readiness of the brain to receive the spirit, consciousness and perception grow, and the attention is fixed on the reality of life.

There are poisonous substances which attack and alter the brain so that under their influence the person acquires another consciousness and lives in another world. Such substances are alcohol, opium, cocaine, hashish. They show that the receiving apparatus for the spirit is sensitive to material influences. But observation of assimilation diseases and of auto-intoxications show that injuries of the brain equally potent and equally severe proceed from unwise feeding.

In the difficulties of life, in the conflicts of the instincts, men solace themselves with such poisons and such food-reactions. You may decide for yourselves whether the highest preparation for receiving the messages of the spirit-principle and

therefore also the purest diet were not the better part.

Involuntarily one's thoughts turn here to the words of the American investigator McCollum: "that diet is an essential, if not indeed the most important factor for spiritual, moral, physical and cultural development and for resistance to diseases."

By means of a heavy, dimly-lighted diet—rich in all the different kinds of flesh and stimulants—people not only invite diseases, they build within themselves barricades against the wisest and most powerful friend of their life, against the spirit.

III

To what conclusions and consequences, now, have all these facts and discussions led us ?

In the new light the human organism appears to us an electronic structure of inconceivable audacity, animated and suffused with spirit, through which in a continuous stream pours the cosmic energy of the sunlight, performing all the work of the maintenance of life and imparting to the substance all the phenomena of life perceptible to the senses. While the plant is directly penetrated and nourished by sunlight, the human organism receives in the food, whose values are all due to the government of life in the plant, the sunlight organised and calculated for its maintenance. Hitherto the energy hidden in food has been called chemical energy, but chemical energy is only in so far food as it consists of the organised spectrum quanta symphonies which proceeded from the rays of the solar spectrum through the production of excited conditions of the molecules. In the vegetable kingdom life-units and food-units are formed from such light-equivalent chemical energy. These are at the energy-level (potential) of

sunlight and are therefore a food of highest nutritive value.

These plant food-units contain everything which the human organism requires, and in the right proportions: enough of the various proteids, a wealth of the best energy givers, the carbohydrates, from which fats can at any time be formed in the organism, or the fats themselves; the minerals necessary for life (the nutritive salts) in the excited state and in the right proportion, and accordingly also the vitamins, or supplementary, or creative substances, which are arousing so much attention. No one therefore need wonder any longer that man can amply nourish himself, grow and keep well with these alone, that ox, horse, stag, roe and even the elephant can build up their proteid-rich bodies from grasses, herbs, leaves and blossoms. Not only the 96 per cent. of energy-consumption in the maintenance of life but also the 4 per cent., the requirement for building up the body-substance, is entirely provided by these plant food-units. There is no reason to fear that their proteid-content will be insufficient. *They are a complete food.*

From now on the nutritive value of all other foods is to be measured by them. The old measures of nutritive value: the percentage albumen-content, the Voit formula (120 grams albumen, 50 grams fat and 500 grams carbohydrate daily for medium work and 70 kilograms weight), the calories measure; all these, which indeed in practice have long since failed, are superseded. A new conception of nourishing value has been created: the sunlight value of a food and the sunlight-level of nutritive energy.

It is true that in the animal economy also the wisdom of life knows how to deal carefully with these nutritive values and to store them up in the

animal body, so that the animal food substances and organs contain them and can serve man as food; but man does not consume the animal in the live state with skin, bones and blood, like the beast of prey. He consumes parts of the animal after it is dead and after more or less elaboration by heat. Thus the original nutritive values suffer a not inconsiderable change. That the European attributes such a high value to "proteid-rich" flesh food is one of his fatal, fundamental errors, on the causes of which I shall speak again later.

The boiling, roasting and baking of vegetable foods is also a not inconsiderable attack on the original nutritive values. One is accustomed to hear the art of cookery everywhere praised and its advantages highly prized; it is necessary then for once to draw attention to its disadvantages. It is true it has extended man's choice of food and avoided many an injury through partially spoilt food. But it has led astray the sense of taste and caused man to forget that food fresh from nature is capable of giving him the best in material and power. The more diseased, the more degenerate a man is, the more he clings to cooked food only. Fresh fruits are often prohibited by the physicians even when they are the only thing that might cure a disease that has lasted for years. "Cooked fruit only" declares the oracle a thousand times. Moreover the art of cookery is guilty of many mistakes. Here I mention only the pouring away of vegetable water which takes with it the dissolved minerals, so that the vegetable residue is impoverished of basic principles and over-rich in acid principles. That boiling destroys the vitamins, that *e.g.* preserves sterilised at a heat exceeding 60 degrees Celsius are an incomplete, one-sided and in certain circumstances a disease-causing food, is a further well-known fact, often

demonstrated in the world-war by its fatal consequences.

But in another way also, independent of heat, people set about degrading nutritive value, *viz.* by tearing to pieces the food-unit—the nutritive energy integral—formed by nature, and using only isolated fragments of it. As classical examples of this procedure you already know :—the polishing of the rice-grain, the preparation of white flour and white bread, and the extraction and refining of sugar.

I have now given you a conspectus of the main lines according to which we may undertake a trustworthy estimation of the nutritive value of human food, an estimation which will stand any test including that of life itself.

According to this, food may be classified as follows:

FIRST CATEGORY

SUNLIGHT LEVEL—ORGANISED UNIT
HIGHEST NUTRITIVE VALUE
PUREST, MOST COMPLETE AND MOST POWERFUL DIET

GREATEST CURATIVE POWER

ACCUMULATORS OF THE FIRST RANK

ALL PLANT ORGANS THAT CAN BE ENJOYED IN THE NATURAL, FRESH, UNCOOKED STATE : ORCHARD FRUITS, BERRIES, NUTS, ALMONDS, VEGETABLE FRUITS, LEAVES, STEMS AND ROOTS OR BULBS, SEEDS, INCLUDING ALL CEREALS.

Lower division : animal food units : *mother's milk, cow's milk, goat's milk, eggs*—in the uncooked state. The nutritive value of these is limited. The mother's milk belongs to the suckling, the cow's milk to the calf, and the egg to the embryo. Moreover the consumption of freshly milked cow's milk or goat's milk is for the most part impossible on account of impurity and of the danger of infection with tuberculosis. Fresh eggs have a composition foreign to human assimilation and can therefore be considered only as a slight supplementary admixture.

SECOND CATEGORY

ENERGY LEVEL MORE OR LESS LOWERED THROUGH THE INFLUENCE OF HEAT. MIXED WITH CATEGORY I, STILL VERY VALUABLE FOOD; FOR CENTURIES THE MAINSTAY OF THE DIET OF THE MASSES.

Used in moderation yields full physical working power, spares the internal organs, maintains health. But used in excess (fattening) is injurious to health.

ACCUMULATORS OF THE SECOND RANK

Here the first place is taken by the following cooked vegetable products; wholemeal bread, boiled, baked or roast dishes of cereals for which the grain with the husk is used, *e.g.* wholemeal, unpolished rice, leaf-, flower-, stem-, and root-vegetables cooked without pouring off the water either in their own water or with a little added water.

First lower division: *further degradation through breaking up the natural nutrition-integral and formation of an incomplete food.* One-sided diet with foods of this category produces very severe constitutional diseases; free use of one-sided foods causes insidious lowering of health.

Such foods are: *white wheaten flour, polished rice, soups, broths and pastry made from white flour and white groats, vegetables from which the water they were boiled in has been poured off, confectionery, fancy pastries, strongly sweetened preserves, sugar.*

Second lower division: *unsuitable composition as in the lower division of the First Category, through the process of cooking and through breaking up the integrals: boiled milk, boiled eggs and egg dishes, white bread and butter, cheese, curds.*

Third lower division: *vegetables preserved by heat.* Here there are several degrees of degradation: relatively good are preserved tomatoes. Weck* sterilisation, or better, Pasteurising is to be preferred to any other method of preserving; and, among trade products, the Hero brand deserves recognition. Coloured green peas and beans in tins are to be altogether discarded.

Further: *condensed milk.*

*Weck is the inventor of a method of sterilising in glass vessels, much used in Switzerland.

THIRD CATEGORY

ENERGY LEVEL DEPRESSED BELOW THE ORIGINAL NUTRITIVE VALUES—

BY MIXTURE WITH ANIMAL TISSUES,
BY THE PROCESS OF DYING,
BY THE PROCESSES OF FERMENTATION AND BY COOKING

Composition not suitable for human assimilation. Overloading of the organs with inferior proteid material. Danger of acid poisoning. Lack of vitamins. Chief source of arthritis. Storing up of uric acid. Unsuitable source of energy for human beings

ACCUMULATORS OF THE THIRD RANK

Fresh meat of every kind, fish, poultry, game, sausages, smoked meat. The flesh of young animals (lamb, calf) is more injurious to health than that of fully grown animals (ox, swine, sheep). In general white meat contains more uric acid formers than red and is by no means to be preferred; the most poisonous are calf's sweetbread, glandular organs and brain.

The so-called edible fungi whose nutritive value comes not from sunlight direct but from decomposing material.

In this new table of values of human foods—it may strike many of you—you find neither alcoholic drinks nor the solaces of all the tired folk: coffee, tea, cocoa, chocolate, maté, kola. They have no place among foods for they are consumed not on account of the admixed food-stuffs but for the sake of their intoxicating and stimulating effects. Their importance and their effects need a separate treatise even when we are all convinced that these luxuries exercise a powerful influence on the processes of nutrition in the interior of the organism. This

influence proceeds not from nutritive values but from poisons. A single mouthful of bread exceeds a glass of beer in nutritive value, and a grape contains more nourishment than a glass of wine. And, to say the least, we pay much too dear for the oats in the oatmeal cocoa and the fat of the chocolate. This doctrine of nutrition has only one drawback: it is in complete contradiction to the valuations and customs which prevail to-day among our people from the highest to the lowest, among the "uneducated" and the "educated." A breakfast consisting of coffee with milk, white bread, butter and jam is considered correct even for growing children. At dinner the flesh dish forms the middle point and the centre of gravity round which everything is grouped. Fruit is eaten, if at all, right at the end when the stomach is full of all the rest. It is scarcely considered as food but rather as a luxury, and many attach no value to its consumption but actually look on it with a superstitious fear.

This nutrition doctrine falls at a time of confusion, of interregnum in the scientific world. The dominance of the old food-values is broken. No one any longer believes in them. Instead, too much value has lately been attached to vitamins and amino-acids. The science of nutrition has become so vastly complicated that only a few really know anything, and for the others there is nothing left but to snap up a bit here and there, and so to simulate a knowledge which after all life requires. Hence it is possible for vitamins to be "produced" in chemical factories, or to be prescribed in cod liver oil, not, if you please, in fresh vegetables. This sort of one-sided precaution tells of anxiety for vitamins, and so completely soothes the disquieted spirits that they comfortably return to the old habits.

What was lacking was the red thread that should

lead out of the labyrinth, the middle point round which everything can be arranged, the measure, the central nutritive value. And this central nutritive value stands now before your minds, firmly realised —*the sunlight value* of the food.

According to what I have experienced and realised in three decades of work as a physician, this sunlight value is in the realm of nutrition the re-discovered Grail, which heals wounds, and has shattered Klingsor's world of illusion.

* * * * *

Despite all false teachings, the wife, mother and guardian of the hearth, has ever defended with tenacious strength the value of the green adjuncts to the table, salads and fresh fruits, the latter especially for the children. In comparison with the Will o' th' wisp reason of man, this does her high honour. To you, ladies, the training of the growing generation of women is entrusted in our land. Your interest in this subject fills me therefore with confidence and joy, for I know of no community, no class, in whose hands I could better have entrusted this theory of nutrition.

FIFTH LECTURE

The power of mother-love—Specific action of certain foods —The task of the sense of taste—Chittenden's experiment— The economy of nutrition—Stimulants—Alexander Haig : Uric acid—The exodus from Egypt.

In four lectures we have travelled together a distance which it took science about eighty years to cover. With many deviations the way gradually led to an eminence where we had a free survey of the whole territory, and an unexpected distant view opened up. The inmost nature of food, the connection with cosmic forces, the wise lordship of life over the energies of space—all this became evident on the way, and enables us at last to recognise the true nutritive values. But in the distance could be seen the possibility of avoiding or of healing many severe, devastating diseases—the promise of a degree of health and a capacity for work as yet unknown, and of a regeneration of posterity.

Arrived so far, knowledge may and should place itself at the service of mankind. But here the doubt arises whether people who have been so sadly led astray as regards nutrition will accept this service, whether indeed they are capable of doing so. Here I am again impressed by those weighty words of the food-physiologist Rubner :

" What countless numbers do not know that their weakened health is due to habitual errors in diet. How many a one has his health injured less by his calling than by unsuitable food. People complain of bad times and deficient nourishment

when nothing is lacking but training and knowledge. And he who knows, what a mass of prejudice and false teachings does he encounter day by day. In this subject, who has enjoyed a real education? Bad habits are rooted in the people and are debilitating them."

So far as this question concerns the doctrine here set forth—I will return later to the rooted habits and the mass of prejudices—you have yourselves an opportunity to form a judgment. You saw that I had to press forward beyond all material conceptions, as it were, beyond the old familiar world-picture into a new world of electrons and of radiant energies to find the secret of food and nutrition,—into a world, still indeed physical yet not to be grasped with our ordinary senses and our ordinary reason. The investigators who have opened up this new world achieved this only through the power of careful and keen thinking upon most delicate observations. In place of the rigid material world they showed us a world where nothing is at rest, in which everything is in harmonious oscillation or in inconceivably swift revolution. There matter exists no longer, only energies. With this new world-picture is altered also the picture of the living creations, the picture of the human being. Man becomes a little world, filled with a systematic revolving and vibrating, interdicted and conducted by an invisible command. We must let the picture of this immeasurable vibrating being become living in our imagination, and take the place of the material human body.

To-day when so many people in the loneliness of their ego suffer so much from feelings of inferiority and impotence, how salutary it would be if they could see and believe that their ego is supported by such a miraculous work of highest wisdom and

omniscience, a source of continuous renovation and inexhaustible powers. At the same time their daily bread also would appear to them in a new light, namely as a secret through which the sun shines and wisdom works. As at the sacrament, food would be transformed for them into something far more ethereal and only to be grasped by the spirit. Every meal, every occasion of taking nourishment would become an event, a joyous and yet reverent festival, and they would not understand how they could have formerly gormandised and gorged so senselessly.

Who then will adopt this new theory of nutrition and make use of it ?—this theory which demands a new conception of the world ?

He who has experience of such matters will not suffer from optimism. The sick will adhere as long as possible to the " shorter methods,"—drugs and serum injections. Only when all else fails do they turn to the wonderful healing power of the right nourishment. And then they expect the food to achieve the impossible. If it will not do this then it is punished, like Saint Antony in Maillebois, whom the mother, because he would not heal her child, placed for eight days with his face down in the waste-bucket. But those apparently healthy will continue to dream their dream of life. Why should they " do different from everybody else "? " Shall I venture not to do what everybody does ? No one will blame me for doing what everybody does. To think thus is to be a servant of humanity."

And yet there are powers whereon one may base one's hope. To these belongs in the first place mother-love, that unselfish power which is active in you, ladies. Hear what MacCann says in his " Science of Eating " :

" In the last 4 years there died in the United States 1,500,000 children under ten years of age.

With their little knives, forks and spoons, with their little hands and fingers they—who were apparently in full possession of their health—they themselves dug their little graves."

Disease and death will continue to speak their heart-rending language, and the guardians of the hearth will open their ears and learn to understand this language better and better. Our hope then is in you, you teachers of domestic economy, that thro' your insight and your practical ability a diet according to the new doctrine may be introduced into the life of the people—and in a sensible way, more diplomatically and more skilfully than the physician could do it. The power of mother-love as the impelling motive of your task will achieve miracles. The children will listen to the mothers, and you know of course that in a certain sense the men remain all their lives the mother's children.

Much depends upon whether this doctrine of the nature of chemical nutritive energy and of the new food-values gains appreciation. It is superior to all existing doctrines, especially to that of the vitamins. In its universality it includes the other doctrines within itself as sub-division—the vitamin doctrine and the calories doctrine, for examples. By it all errors of diet are mercilessly laid bare. For many it may not be easy to penetrate to the new world into which it leads and to form a vivid concept of its truths. But your attention and your keen interest assure me that to-day this is not impossible for thinking persons trained in natural science.

In the longing for a conception of the universe such as is found *e.g.* in Ostwald's *Lectures on Natural Philosophy*, in Francé's *Zoësis* and *Laws of the World*, and in the popular biological-medical works of Schleich ; also in the impetus the natural sciences have received from the discovery of radium to the

theory of Einstein and the atomic model of Bohr, there is revealed a mighty regenerative power of the human mind, ready and capable of clearing the way for the new nutrition doctrine.

Let then the ever negative spirits of inertia and of bad habits put forth their powers in opposition ; on the truth and on mother-love they will be shattered, " La verité est en marche !" (Truth is on the march !)

I

The Specific Action of Certain Foods

Popular belief, which is often the last tradition of primitive knowledge, ascribes to certain foods a special curative effect in sickness. This is especially so in the case of fresh fruits, berries, vegetable fruits, roots and also green leaves.

Radishes and radish-juice are said to cure gall-stones. While some—unjustifiably—prohibit tomatoes, on account of their oxalic acid, in the case of stone in the kidneys, others ascribe to them and to cucumbers the power of dissolving these stones.

The botanist, Linnaeus, treated his gout with strawberry-cures. Equally well-known are lemon-cures, grape-cures, and greengage-cures. Manifold also are the results attributed to whortleberries.

Such cures are often carried out in a very one-sided and exaggerated manner, or simply thrust in on top of the usual, for the most part unsuitable diet, whereby their beneficial action is endangered or the digestive organs overloaded and injured. Only the future can show how far we have here to do with specific curative action or simply with that common to all fresh fruits ; for with proper use the great curative power of fresh fruits in general is

very probably capable of bringing about all the results claimed.

The dietetic action of the vitamins gave the most striking example of specific results. You remember the Beriberi disease in the case of consumers of polished rice and white wheaten flour. The addition of the silver membrane of the rice or of the bran of the wheat cured the disease. But even a diet of whole rice and whole wheat would not be capable of preserving health, since the grains contain too little of the A-substances. The disturbances thus occasioned, emaciation, inhibition of growth, lack of appetite, disease of the cornea, are avoided or cured if with the cereal diet are associated sufficient fruits and green leaves, which contain plenty of the lacking A-substances.

A quite essential influence is exerted by the content of the food in mineral substances ; and of these some, *e.g.* sodium, potassium and calcium, act as bases, while others, *e.g.* sulphur, chlorine, phosphorus act as acids. Acids and bases must counterbalance each other in the organism. A diet containing a constant excess of acids (this is especially true of every diet rich in albumen) brings about lack of bases and therewith an insidious undermining of the health. The introduction of a diet poor in acids and rich in bases would here exert the specific healing action. But also each particular mineral has its specific action, as I have already said. Recently the interest of investigators has been directed to potassium, which alone of the biogenic minerals exhibited radio-activity. It is known to possess special importance for the muscles of the heart, the fine muscles of the walls of the blood vessels and the glomeruli of the kidneys. A lack of potash must prove disastrous for these vitally important tissues. But here we must not forget for a moment that we are speak-

ing of the potassium atom organically combined by life in the sunlight (irreplaceable by any inorganic potassium), of potassium atoms whose outer electrons have been diverted into orbits further from the nucleus, of potassium atoms in the excited state.

But not only potassium (or rather foods which contain sufficient quantities of potassium) has this specific action but also every one of the biogenic minerals ; I may mention iron, manganese, fluorine, iodine, silicic acid, phosphorus, calcium.

Please note that the specific action only comes under observation when through lack of the particular food-constituent injuries to health have occurred, which are rectified by the supply of what was lacking. The investigation of disease-conditions caused by deficient nutrition, including the many which occur unsuspected, opens the prospect of valuable new discoveries and observations.

Specific actions are also often ascribed to animal organs. This is due partly to primitive notions of magic, partly to poisonous effects and only to a limited degree to real specific actions of the organs. The first corresponds to the belief of the cannibal who consumes the heart of his slaughtered enemy in order to incorporate the enemy's courage in himself. The second you find in the belief in meat extract, in the calf's thymus, the brain and the flesh of young animals (lamb, chicken, pigeon) which still unfortunately play a great part in sick-diet and convalescent diet. The specifically active in all these dishes is their content in substances yielding uric acid which exercise a peculiar poisonous stimulant active on the organs and tissues. The third case is that of the glands secreting internally (thyroid, suprarenal capsules, pancreas, ovaries and testicles) whose secretions (hormones) exert in the healthy organism also an important regulating

function on metabolism and life. If now the organism falls ill because the thyroid gland, *e.g.*, is atrophied, or because too much of it has been cut away, the specific action of animal thyroid is shown in an improvement of the symptoms when the patient takes a carefully measured small quantity of the gland. The so-called myxoedema diminishes. In the case of diabetes whose ultimate cause is frequently an injury to the " island " substance in the pancreas, a specific action has been observed to follow on the administration of insulin, a preparation of that island substance. The like has been observed in the case of disturbances in menstruation, on giving preparations of the ovaries (ago-mensin and sistomensin). Here belong also the effects due to implanting generative glands, as lately made known by Steinach. But in the case of the suprarenal capsules this specific action is lacking. In Addison's bronze disease, which is caused by destruction of the suprarenal bodies it is not possible to bring about an improvement by giving suprarenal preparations.

These specific organ-reactions I have keenly watched and my experience of them has been less and less satisfactory. Apart from the fact that they are accompanied by not inconsiderable poisoning effects, even the best results are unsatisfactory and always temporary. I have seen better and more lasting results from an alteration of the whole system of diet in accord with this new doctrine of nutrition. From the first lecture you will no doubt remember that the vitamin investigations revealed a hidden essential connection between the vitamins, the hormones of the internal glands, and the sunlight. On connections of this kind depends the specific curative action of accumulators of the First Rank in diseases of internal secretion.

The specific action of animal organs is accordingly

in my opinion even at its best of but little value and more is effected by a diet of the most natural nutritive values possible, for this includes in itself all the specific nutritive results that can possibly be desired, of the vitamins, the minerals and the hormones. Only in the case of deficient diet is there any need at all for specific food action. A full diet in our sense knows no avitaminoses and no disorders of the internal secretion. But where such disorders have been produced through a deficient diet, there is no food however " specific " which is superior to the properly carried out sun-value diet.

All this is already firmly established to-day and is supported by manifold experience. But how few know it. All round us our fellow men remain in their dietetic errors and are lulled into security by habit and out of date teaching. So they wait till the deceptive peace is broken by the pains of gall-stones or kidney-stones ; and then at last if they are well advised, they are cured by radishes, tomatoes and cucumbers. A fine task there awaits the sensible teacher of domestic economy.

II

The Task of the Sense of Taste

Even this little sketch of specific nutritive actions has once more shown us how various and complex must be the composition of a full human diet, and how every single particle must be blended in definite proportions with certain of the others or with all. When one considers that all these proportions have only lately become known, and that to-day there are many others just as little known as were formerly those that we now know, it becomes plain what an

impossibly difficult task would devolve on the human understanding if with its knowledge it had to atttempt the right composition of an adequate diet. And yet this problem must be solved, indeed solved every day, solved at every meal. Health, capacity for work and the welfare of the coming generations depend on it. We do well then if at length we recognise that the Creator, the Wisdom that works in life, has solved this task beforehand. It was men who first tore asunder all proportions in food and so disturbed the whole harmony that grave diseases supervened as a necessary consequence. Remember the polished rice, the white bread, the proteid excesses, the refined sugar.

But the Creator has not only solved the problem in the food, he has also given man an accurately deciding judge, to protect him from an imcomplete denaturalised diet—the SENSE OF TASTE. Man however, managed to make this gift also unworkable. Involuntarily I think of the parable of the talents which the Lord entrusted to his servants. The servants buried the sense of taste under stupefying stimulants of taste, alcohol, strong spices, tobacco, roast products, fried products, and began to gulp down their artificial dishes so quickly that the sense of taste did not find time to form a judgment. The result is the confusion, the lack of all guidance in which the process of nutrition and the human metabolism find themselves to-day, and also—a host of devastating diseases.

America, the country where the nutrition-folly raged most mischievously, caused one of her sons Horace Fletcher, to come to his senses, and to set the sense of taste again in its place of honour. Through careful, systematic chewing, and through obedience to the demands of his sense of taste Fletcher found the composition and the quantity of

food which cured him of a grave nutrition disease. Then he wrote his *A B C of Nutrition* and his teaching made an impression. People again began to pay attention to taste. Fletcher discovered that his taste led him away from animal food rich in proteid to vegetable food and to a wonderfully small quantity thereof.

Subsequently the diet-physiologists, Chittenden and Irving Fisher, made the same observation on themselves and on quite a number of subjects of experiment, among them in particular professors and physicians and students of medicine. Of Chittenden we shall speak again presently. Irving Fisher experimented with a view to showing to what diet taste would lead if a man was trying to attain the highest physical achievement and endurance. Without exception his group of athletes forsook animal food and adopted a vegetable diet, also diminishing the quantity of food.

It is for man, then, to restore its influence to this gift of God, the sense of taste. And it will certainly and definitely lead us back to our sun-value diet.

III

The Economy of Nutrition. Chittenden's Experiment.

You have just heard that Fletcher, Chittenden and Irving Fisher, through their researches, came to recommend a quantity of food as small as possible, but just sufficient, and this when taking a predominantly vegetarian diet. This is the more striking since according to a widespread opinion, supported especially by medical authors, in order to be able to nourish oneself at all on vegetables one

must eat vast quantities of them ; some, who have certainly never tried it, like Albu, go so far as to declare that one must eat vegetables the whole day long. Nothing is more capable of discrediting a vegetarian diet among the ignorant than such a statement. The peculiar aberrations of the feeling of satiety among flesh-eaters and large-eaters mislead them into rashly believing in these aberrations. And yet nothing is more false than this statement. He who gives up flesh food and, for fear of being hungry, crams himself with great masses of vegetables, will have a very bad experience of this new diet. Not only will he not succeed in nourishing himself adequately, but he will very soon ruin his digestion. Vegetables do not consist of such decomposible inferior material as animals. Their nutritive value is so high that in modest quantity they suffice for full nutrition. Accordingly the digestive organs will not be overloaded with them; otherwise they work badly. While in our country wherever much meat is eaten there is a tendency to intermediate meals, to five meals a day, with the new diet one chief meal and two subsidiary (night and morning) suffice. When the transition stage, let me say it plainly—the stage of clearing out the poison—is over, one feels with these three meals completely satisfied well nourished and fit for continuous exertion. That is the truth ; the other, the statement about the masses which one has to be eating the whole day, is a lie !

But let us see how the great experiment of Chittenden turned out, that experiment which stands alone in the annals of dietetic sciences. Chittenden assembled around him a group of 26 men : professors, physicians, medical students and soldiers of the sanitation corps, all ready to submit themselves for six months to the conditions of the experiment in

diet. These conditions were : We eat the minimum of proteid and the minimum of calories with which we can maintain completely a feeling of well-being, capacity for work and mental freshness without any sacrifices.

The twenty-six were divided into three groups according to occupation :

1. Professors .. .. 5 men
2. Moderate workers—volunteers from the sanitation corps .. 13 men
3. Doing hard muscular work, athletic students .. .. .. 8 men

In the first group Chittenden himself took part in the experiments.

The experimental diet was as varied as possible ; it contained meat dishes among others. Those taking part were instructed to limit the consumption of dishes rich in proteids more and more. This led naturally to a considerable reduction in the consumption of flesh and eggs.

Now listen to the results : the general average of the daily consumption of proteid amounted to approximately 50 grams (as against 120 grams according to Voit). Chittenden's average was 33.73 grams proteid per diem.

Equally surprising was the result as regards the consumption of energy. Voit had demanded, for a man on average work and weighing 70 kilograms, 3,000 calories a day. This amount was attained only by a maximal worker of 75 kilograms weight, an athlete of the third group. The medium workers kept within 2,500 to 2,800 calories ; the group of professors averaged 2,030 calories a day. Chittenden consumed only 1,600 calories.

You see then : reduction of the usual proteid consumption by five-twelfths to a third, no compen-

sation for the diminution of proteid by increase of other nutritive values; on the contrary reduction of the consumption of energy to an amount considerably below the average demanded. And in spite of this every one performed a full day's work, some of them an extraordinary amount of work, and with uninterrupted good health.

Of himself Chittenden reports: a change to vegetarian diet was not intended. But there arose, and there continues to-day, a tendency to exclude flesh food. The change to the smaller proteid ration occasioned at first some discomfort which however, soon disappeared while personal interest increased through finding oneself undoubtedly in better physical condition. A rheumatic disease of the knee joint which had existed for one and a half years and yielded only slightly to treatment disappeared completely and has never returned. Headaches and digestive troubles failed to make their usual periodic appearance. On the other hand there were observed a greater appreciation of food, a more marked appetite and a keener taste with decided preference for simple fare.

With his capacity for work during the experiment Chittenden was well satisfied. He is ready to maintain that he worked more and in every respect led a better life, that he felt better and less tired than usual, indeed that he always felt in the best of health.

I must refrain from reporting to you all the interesting results of this experiment and the instructive conclusions drawn by the chief experimenter, although it is extremely desirable that Chittenden's works should be generally known in our country.*

*For those who read English I give here the titles of his two popularly written publications: Russell H. Chittenden, *Physiological Economy in Nutrition*, London, 1905, Heinemann, and *The Nutrition of Men*, New York, 1907, Stokes.

But the main result of these scientific researches, which originated at the instigation of Fletcher, must be noted, viz., the proof of the economy of the nutritive function.

Feeding in excess of requirements does not make one stronger, more capable of work, nor healthier nor more capable of resisting diseases. The best physical state of health is attained if one takes what is necessary with a minimum of proteid. Thereby man attains also his maximum of strength, capacity for work, and endurance.

This the mothers should note for the sake of their children. A fat child is no healthy child. This all who would excel in sports should note in order that they may not by over-nutrition prevent their bodies from doing their best ; and this the physicians should know in order that the cramming cures may definitely disappear.

IV

Stimulants—Alexander Haig : Uric Acid

So far we have spoken of food only as the carrier of building material for the organism and as the source of energy for the maintenance of life. Side by side with, and often together with, this real food man consumes substances which do not feed but which produce pleasant feelings and conditions of stimulation, followed by discomfort and debility. The unpleasant after-effect may be dissipated by a renewed dose of these substances, but gradually more and more of the stimulants must be used to restore the sense of comfort. The theory of these substances has nothing to do with the theory of

nutrition in the narrower sense, but their use is in life so intimately connected with the consumption of food, and their effect on the choice of food and on health is so important that they cannot be excluded from a treatise on human nutrition.

To these stimulants belong the alcoholic drinks and the purin substances or uric acid producers, which are found mostly in flesh food, in meat extracts, in the beverages coffee, tea, cocoa and in chocolate.*

I can and must omit to speak here of the alcoholic beverages, since the alcohol question is sufficiently familiar. Alcohol is after all a poison that acts so quickly that the injuries it causes cannot, with the best will in the world, be overlooked, short-sighted as men are in these things. With the purin substances it is otherwise. Their action is spread over much greater periods, over a whole life time, and, coupling itself as it does with errors in nutrition, even over generations. It is therefore no less fatal, and more treacherous, because the consequences escape the observation of short-sighted human intelligence. I greatly regret that the few minutes which remain to me do not permit me to give you a conspectus of the whole extent and the colossal importance of the uric acid diseases, of arthritism, as the French and English physicians term this domain. But I will at least tell you of one physician who has devoted his whole life to this question.

You know that sick headaches, acute and chronic, are a very obstinate trouble which is accounted the

*Purin substances: In all the numerous substances which are present in flesh food, in meat extract, in coffee, tea, cocoa, chocolate, as precursors of uric acid, the Berlin chemist, Emil Fischer, discovered a common nucleus which he called purin. Purin substances is accordingly the collective name for this whole illustrious family.

first stage in psychic degeneration. Now the English physician, Alexander Haig of London, suffered from this disease. He narrates how, when no remedy was found effective, he saw himself faced with catastrophe. Then he was advised to try a change of diet, viz. to refrain entirely from mutton. He followed the advice and—his headaches diminished. At first he still ate fish ; when he gave up this also, the attacks became still rarer.

It was then evident that his headaches were the result of his diet, and that this was why no drug had been able to help him. But what was the nature of this connection ? In medical science nothing was known of it. To this question he now devoted his whole attention.

The first discovery was the connection with the uric acid content of the urine and of the circulating blood. Every attack was preceded by an increased flow of urine with diminished uric acid excretion, and followed by a diminished flow of urine with high uric acid excretion. Parallel with this there was a preliminary diminution of the blood uric acid with increased vitality, and a succeeding flooding of the blood with this substance and then an attack. From this he concluded: The cause of my attack of headache is a storm-like poisoning of my blood with uric acid. Then, when the uric acid that has invaded the blood has been excreted in the urine, the headache at once ceases. But this invasion of the blood by the uric acid is preceded by a dearth of uric acid in the blood, a sign that the uric acid is retained in the tissues, and this retention is just as important for bringing about an attack as the succeeding flooding. During the process of retention in the tissues, Haig noticed a peculiar prickling, and tearing and even pains in the members, joints and often also in other parts of the body ; during

the flooding of the blood on the other hand, swelling of the liver and disabling of the function of the stomach and intestines, whereupon decompositions in the intestines led to evil-smelling stools. If the blood was poor in uric acid at the time of the retention, he recognised in his capillary-vascular system a free quick flow combined with general well-being ; if it was rich in uric acid the flow slackened more and more, finally the skin took on a bluish colour, and if by pressure with the finger he pressed the blood of the skin out of the capillaries there appeared a white spot which only very slowly filled again with blood—the phenomenon of delayed capillary reflux. The next discovery was that in his body retention and flooding alternated periodically according to the time of day, and this in accordance with the ebb and flow of blood-alkalinity already established by the investigator of gout, Sir A. Garrod. The higher the alkalinity the greater the uric acid content of the blood, highest in the last hours of the night. If the uric acid content on awaking in the morning was abnormally high, he experienced a heaviness in the limbs, general languor, with delayed capillary reflux and concentrated urine ; and it was 11 a.m. before he could record that the blood was beginning to free itself from the uric acid poisoning.

Soon Haig realised that there existed a periodicity not only according to the time of day but also according to the time of year. Cold produced retention, warmth flooding of the blood ; hence in winter, retention, storing up of uric acid in the tissues ; in the spring, with the first warmth, invasion of the blood ; in June, with the reversion to cold, uric acid again driven back with conflict between retention and uric acid flooding ; in summer and autumn the acid dissolved out of the tissues and excreted in the

urine. If the retention of uric acid was very considerable there resulted rheumatic diseases of the joints and muscles; if a long and severe period of solution and excretion followed, it might happen that the uric acid formed in the blood little flakes like snowflakes, and for a long time disturbed the circulation, and all sorts of diseases occurred, such as liver pains, chronic dyspepsia, asthma, catarrhs. This condition of the blood Haig called uric acid collæmia.

Haig convinced himself and to a great extent furnished proof that uric acid plays a causative rôle in the production of many diseases. Corresponding with the two mutually opposed processes he saw the development of two groups of diseases of different nature. The retention of the uric acid in the tissues, which ever and again free the blood from excess of uric acid leads to the formation of a growing deposit of uric acid in the tissues, a slowly increasing state of irritation which finally manifests itself in chronic rheumatism, gout, diseases of the lymphatic glands, skin diseases and a diminution of the power of resistance against infection; furunculosis, tuberculosis, wound infections. From the temporary flooding which causes sick-headaches he saw develop permanent conditions of overloading of the blood with uric acid, collæmias which become the cause of more or less severe stomach, intestinal, liver and kidney pains, of bronchial catarrhs, asthma, of heart diseases, at first functional then organic, of diseases of the walls of the arteries (arterio-sclerosis) and of the veins (phlebitis and thromboses), of vaso-motor disturbances leading to Raynaud's disease and to Basedow's disease, with which the thyroid gland is known to be involved; of high blood pressure and of periodical or permanent states of depression and blood diseases.

Haig's chief work was entitled: *Uric acid as a factor in the causation of diseases. A contribution to the pathology of high blood-pressure, headache, epilepsy, mental diseases, paroxysmal hæmoglobinuria and anaemia, Bright's disease, diabetes, gout, rheumatism and other disorders.* Here he publishes the results of his extremely interesting five years researches on his own body and on many patients. Here for the first time in the whole history of medical pathology appears an inner connection between all these very different diseases.

Haig then tested the question, in what way and by what means these uric acid processes in the blood could be influenced. He found that, besides drugs, inorganic acids, alcohol, and—what was the solution of the riddle—uric acid itself and all its precursors (xanthins, purins) cleared the blood and drove the uric acid into the tissues, whence it then presently returned again, as soon as there were again sufficient bases collected in the blood. He succeeded in attaining such a mastery over these processes that he could produce and cure sick-headaches at will.

More difficult, much more difficult was it to dissolve the uric acid once it was stored up in the tissues, and to bring it to excretion through the blood. For this the uric acid patient had to accommodate himself to a diet which so far as possible avoids the introduction of new uric acid precursors, and at the same time brings to the blood a permanent excess of bases. Further he must resign himself to endure for a longer or shorter time according to his uric acid condition the unpleasant effects of blood charged with uric acid.

Since, with the sort of diet that is generally customary to-day, every one carries in his tissues a deposit of uric acid small or large, this transition stage of uric acid elimination becomes the greatest

obstacle to an improvement in the diet. The discomfort caused by collæmia is regarded as proof that the new diet is not sufficiently strengthening, is not well borne. In order to escape the collæmia one returns as soon as possible to one's former uric-acid-rich diet and beverages. And then there is the unfortunate fact that even the physicians know nothing of this uric acid deposit, of its slow elimination and the disturbances connected therewith, so that they too regard the collæmia symptoms as a proof that the new diet, though it has just initiated the process of cure, is worthless. And yet it would be so easy by testing the urine to convince oneself of the beginning and the course of this process. And so out of pure misconception many diseases remain uncured. The uric acid deposit only begins to gain credence when indubitable gouty joints have formed. Very late, often too late !

What is the source of this uric acid which by a long drawn out gradual process imperceptibly effects the most cruel depredations in the marvellous structure of our organism, so affecting the sensations that to escape depression the victim has recourse again and again to fresh doses ? This source in all its Protean forms was discovered by Haig. The source is flesh from the slaughter house, the white meat more than the dark, and chiefly the cellular gland organs ; also fish, poultry, game, eggs, dried beans and peas, and then the stimulants, coffee with its caffeïne, Asiatic tea with its theine, cocoa and chocolate with their theobromine.

A wholesome and curative diet, then, must severely limit these foods and stimulants, or better in the case of children and of serious illness, abandon them altogether. To those who have the flair for hidden connections it may be a pleasant surprise to find that the sun-value diet fulfils all these demands

on nutrition, arising from quite another quarter, completely and without exception.

What is here so briefly and scantily reported might be supported, developed and extended by an enormous mass of experience. Let me at least indicate two more confirmations. You all know the widely distributed disease, arterio-sclerosis, called from its last stage arterial calcification.

In the course of its development which lasts for decades, high blood pressure, strokes, severe heart pains, shrivelling of the kidneys and psychic disturbances to the point of madness, set in. Few have any idea to what an extent family life is injured by this disease. An example : In a family here arterio-sclerosis, setting in early, had turned the father into a narrow-minded, passionate tyrant in his treatment of his wife and children ; in money matters he was altogether unreasonable and unbearable. The greatest sufferer was the eldest daughter who had been from birth abnormally sensitive, which caused the father to oppress and torture her all the more. One morning when the mother, contrary to her custom, appeared first at the breakfast table, she was surprised to find the father's cup already filled with coffee. She examined the contents and discovered that they consisted, to the extent of more than half, of pure hydrochloric acid. Exasperated to the uttermost, the child had determined in this way to rid herself of her father. But who shall measure the suffering, the tragedy in this child's soul, before she resolved on this deed ? Such are the effects of arterio-sclerosis.

Now a great French clinician, Huchard, had chosen this disease as his special subject. On this he became the greatest specialist of his time. His final verdict was : " There is only one remedy for this disease, and I have told you this, my fellow-

physicians, again and again without gaining a hearing; and this remedy is a vegetable diet." The agreement with Alexander Haig is, as you see, perfect.

As you will remember Haig had recognised that uric acid lowers the resistance to infection, in particular to tuberculosis. Quite recently this connection has been confirmed by a French lung-specialist, the physician Paul Carton. According to him arthritis (so the French physicians call the whole range of diseases in which according to Haig uric acid plays the causative rôle) is the soil on which in the third generation tuberculosis begins to flourish. In spite of all this the high feeding of the tuberculous, especially with meat and proteid-rich foods, is obstinately persisted in. The fact is that in the case of lung disease or consumption the popular imagination is oppressed with the fear of losing strength, and therefore people cling to the deceptive powers of the enchanted realm of Klingsor, on which they have staked their last remnant of faith. So then, tuberculosis, arterio-sclerosis, assimilation diseases and cancer will continue to increase and to destroy the best powers of mankind, unless at last in the nutrition question light shall dawn.

In this expectation of the dawn of the coming light, end to-day my lectures on the theory of nutrition. If the new theory has succeeded in gaining your interest, if you now go forth with the intention of exorcising these dark spectres, all these nutritive follies in school and home, among high and low, then you may make up your minds to a hard struggle. I speak from experience. You will find but little honourable, scientific opposition, but much that is unexpected and surreptitious. In the psychic realm prejudices and false theories correspond to the unknown and little understood effects of uric acid in the blood on the general feelings and their checking of the circulation in the transition

stage. Adults to-day are not simply human beings, they are depositories of uric acid on the way to gout, to arterio-sclerosis and to other grave diseases. All these will obstinately defend their own way of life—the beloved dietetic habits—so long as their sufferings have not become unbearable. Indeed they are such uric acid depositories long before sufferings or strokes occur. But if your patience does not become exhausted, if it does not become too wearisome for you always to encounter the same old oft-refuted opposition, and to be constantly obliged to say over and over again the same thing, you will very soon experience a great joy. Many a symptom of disease that previously would yield to no remedy will yield to the new diet : *e.g.* constipation, an enormously prevalent disorder, especially disastrous for women. In the course of the 28 years during which I have had the experience of opposition and of overcoming it there came into my consciousness, at first haltingly and then gradually more and more strongly, a parable which pictures at once the gravity of the task and the course events must take. It is drawn from the early history of mankind, the exodus of the Israelites from Egypt, as narrated in the Bible. There enslavement in Egypt ; here enslavement to the sources of uric acid. There the land of the wonderful grapes and of freedom—Canaan ; here health, well-being, joy in life, children growing strong on a natural, wholesome diet ; and then, in between, the way through the desert, the way of knowledge and of faith, the crying out for the flesh-pots of Egypt, the repeated defections, forty years of wandering ; and none who had seen Egypt reached the promised land alive. Only the new generations will be able to enjoy the full blessing of the regained freedom.

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